PRODUCT ENGINEERING
MCGRAW-HILL PUBLISHING CO., INC. VOLUME THREE, NUMBER TWO
FEBRUARY, 1932

Engineering Politeness into the Big Ben Chime Alarm

Transforming the sincere sleeper's nickel-plated nemesis into an attractive and friendly piece of home equipment was an artist's job, but eliminating the "tick" and developing the double alarm called for genuine engineering originality

An Interview with
W. S. HAWTHORNE
Works Manager, Western Clock Company

BIG BEN CHIME ALARM, the two-voiced silent-ticking alarm clock, is finished in nickel plate and velvet black lacquer

MINOR REFINEMENTS in the mechanism or appearance of a consumer product are seldom sufficient to capture a market in these times. It takes radical change to enthuse the customer. Each change must be calculated to give him something he has long wanted, even though that want has never found articulate expression. The public's quick acceptance of the Big Ben Chime Alarm is a striking tribute to the soundness of this philosophy.

It should be remembered that alarm clock improvement for years had been confined chiefly to appearance changes, the addition of color, and so forth. However, the engineers and executives of the Western Clock Company had suspected for quite a while that more could be accomplished in the way of actual performance.

While the average consumer is content to remain silent on manufacturing suggestions, a few voices were heard from time to time, and these checked with the company's opinion that alarm clock improvements should not stop with changes in appearance. People wrote in to ask why an alarm clock had to have such a noisy tick, why it had to sound like a fire alarm and shock people half out of their wits. And in addition to this, articles were being run in various publications over the names of eminent doctors telling how the

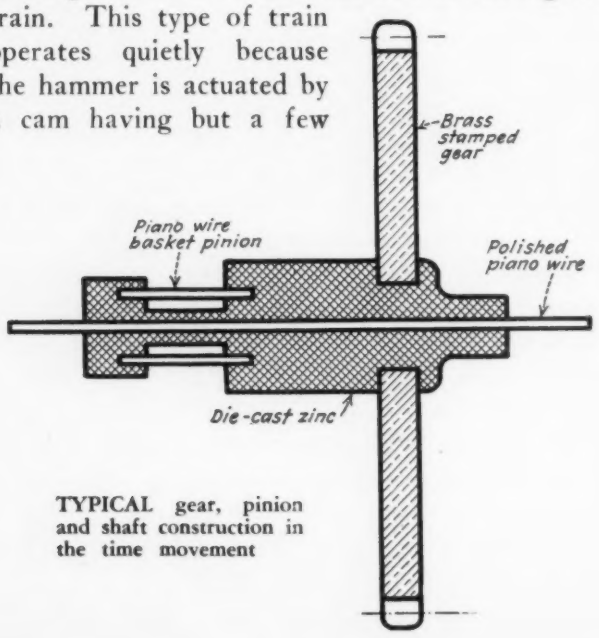
shock of alarm clocks hurt the nervous system.

From the tone of the letters that came in from consumers it was apparent that they had entertained no more than a hope, however, for there was nothing of a definite nature in their suggestions. So the new Big Ben came about through the desire to develop something entirely new—something that would remove the old curse of alarm clocks and fit in with people's ideas of pleasant awakenings. A clock that gave some sort of a preliminary signal before the regular alarm sounded gave promise of having real appeal, but no one was sure such a clock could be made.

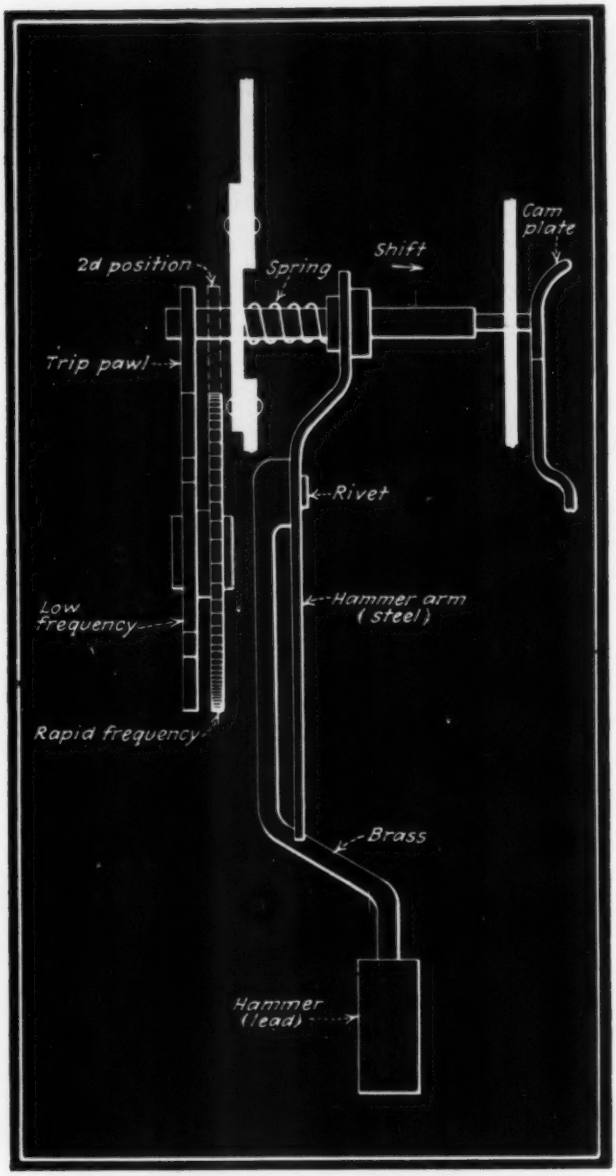
One of the first models that was built gave a number of taps some time before the alarm started to ring, but the interval was considered rather long for some people whose morning time is valuable. This alarm operated by a double cam which released under the tension of a trip spring.

Later, a clock was developed with the idea of offering a choice between a soft, mellow alarm for the light sleeper and a loud alarm for the deep sleeper. However, when the alarm was set on mellow, the internal noise of the moving parts was too audible and disturbing. A further attempt was made along the lines of the first model by reducing the time interval to about five minutes. This was done by adding a separate cam for the second trip farther away from the center of the trip wheel, thus increasing the speed at which the second trip would start. This mechanism also proved unsatisfactory.

Finally the demand for such a clock was interpreted as an appeal for an alarm clock having a mellow alarm, a sort of a reserve call. In the first attempt at this a train similar to that of a striking clock was used in addition to the regular train. This type of train operates quietly because the hammer is actuated by a cam having but a few lobes, or teeth. The result was pleasing. As in the second model of the warning clock, the shift from the chiming was actuated by means of a double cam. The interval was fully taken up by the striking of the clock. This movement had two switches with which a variety of combinations could be worked out. However, this interval was questioned as being too long, and there was objection also to the cost of an extra train.



TYPICAL gear, pinion and shaft construction in the time movement



UNDER SPRING PRESSURE, the hammer spindle shifts to the right, when released by the cam plate, and brings the rip pawl from the low to the rapid frequency ratchet, producing the two-tone effect

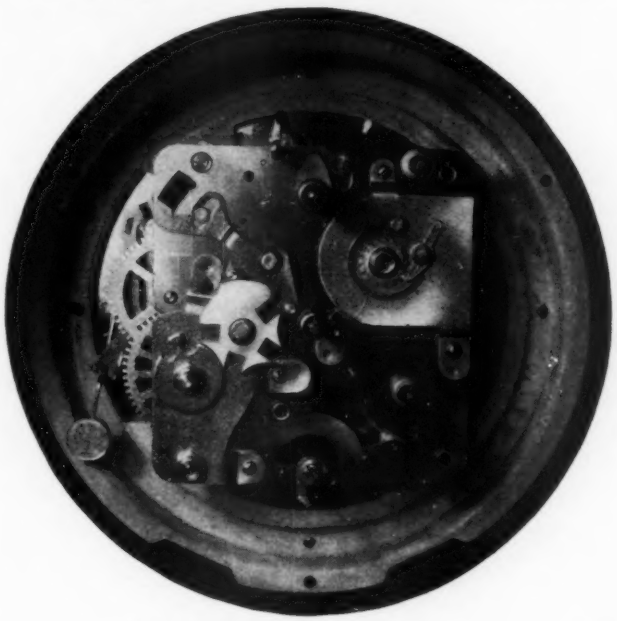
Finally, the mechanism incorporated in the present model was hit upon. In it the two features of a mellow chime, followed by a loud alarm, are combined in the one train by using two cams, or ratchets. One has a low number of teeth, such as used in the previous model, and another a greater number of teeth. The chief problem was to produce a mechanism that would

cause a loud alarm to follow the chiming automatically. In the present mechanism the hammer is shifted from one cam to the other by means of a Geneva stop motion and a wedge cam that moves the hammer shaft axially. With this mechanism, the hammer taps the gong slowly for about 20 seconds, then strikes hard and quick.

A number of experimental movements were made up to find the best gear ratio and the proper place of power application for moving the hammer in order to get low speed and low power for the chime alarm with high speed and high power for the regular alarm.

While the study of the two-tone alarm proceeded, parallel studies were being made in the silencing of the tick. This ticking noise is located in the escapement; that is, the part that regulates the time intervals, and consists of the escape wheel, pallets, lever, impulse pin and balance. These parts ordinarily are made of brass or hard polished steel. The noise is made by alternately releasing and stopping these parts. In the first attempt to reduce the noise, violin string was substituted for the steel pallets and the impulse pin, but the wear of this string as pallets being questionable, cat gut was substituted for the steel pallets and impulse pin because of its tough qualities. Later, waxed thread was tried for replacement. While the noise was greatly reduced by using these materials, they were not considered adequate to withstand the wear, since the pallets must take the impact of some 18,000 blows per hour.

Next, a phenolic resin compound was used for the escape wheel and lever. This solution did not prove to be satisfactory, because of manufacturing difficulties. Some time later, this problem was therefore approached from a different angle. A movement was mounted on a molded bracket, and although there were some difficulties which ruled out this material, it led to the final solution of mounting the movement on four soft rubber grommets. Independently, the same principle of vibration damping as adopted for the floating power plant of the new Plymouth was reached. A similar arrangement is being used also for the mounting of a vacuum cleaner motor.



ON THE BACK of the clock movement is the Geneva movement for producing the two-tone chime effect. On the right of the Geneva wheel is a cam lobe with bearer pin in the arm of the wedge cam plate (further to right)

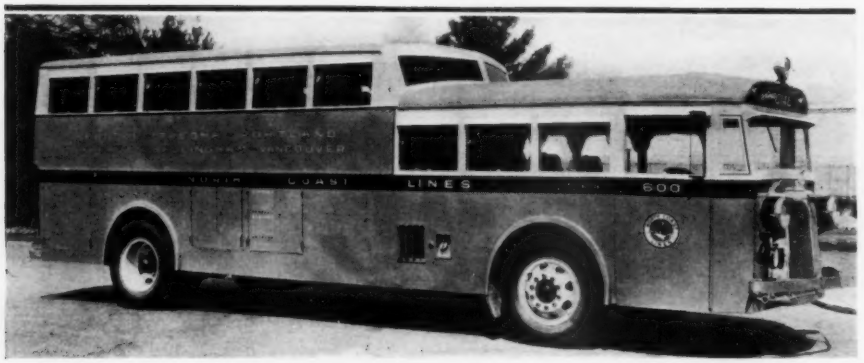
This method of mounting necessitated a complete change in the design of the clock. In the type of mounting used on the former Big Ben, the movement was fixed to the back. Merely to substitute for the steel lugs a soft rubber mounting is not practical, so the mounting is placed in front of the movement, by means of a movement holder, onto which the dial is assembled.

With the performance of the clock assured, the next step was to produce a case of pleasing modern lines. A hand-made model, built from sketches, was made up with production in mind and submitted to a consulting artist. A two-toned case and a base that harmonized beautifully were designed. The case consisted of two drawn brass shells, finished separately, one in velvet black lacquer, and the other in nickel plate. The center part of the case was slipped over the nickeled front, which was tapered off. The same is true of the back, which formed the gong. Approving the design in principle, the artist concaved the tapers to eliminate the barrel effect and made changes in the base, which is a zinc-base die casting. A bronze lacquer is used on the under side of the die-casting. Felt pads are placed at the four corners to prevent marring of furniture. As finally designed, the case is smaller and thinner than previous models, to conform with ideas of what the sales force thought would sell. A more legible dial with gracefully pierced hands finished in gun metal was added by the artist.

Before the product was introduced to the trade the new clock was given various accelerated wear tests on the operating parts, tests in a sound-proof room, and tests of timekeeping under both hot and cold conditions.

It is interesting to note that before the Big Ben Chime Alarm was announced, production figures were set at 2,500 pieces a day. Then came the consuming public's reaction. The new clock "clicked" and production soon had to be stepped up to 4,500 per day.

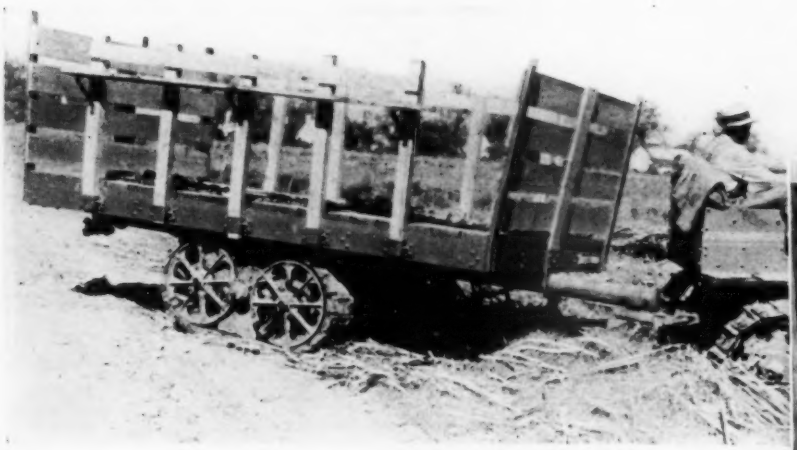
The MONTH



With all-steel welded and riveted frame and duralumin sides, this Interstate deck-and-a-half coach accommodates 32 passengers, seven in front, 25 in rear. Engine has rubber mountings and is sealed in an insulated compartment amidships

GMC 10-ton highway freighting truck with 10-ton trailer, each weighing 34,000 lb. loaded. A Timken dual-drive compensating rear-end drives all four rear truck wheels. All wheels are dual except front truck. Both bodies are Dry Zero blanket insulated with aluminum exterior finish

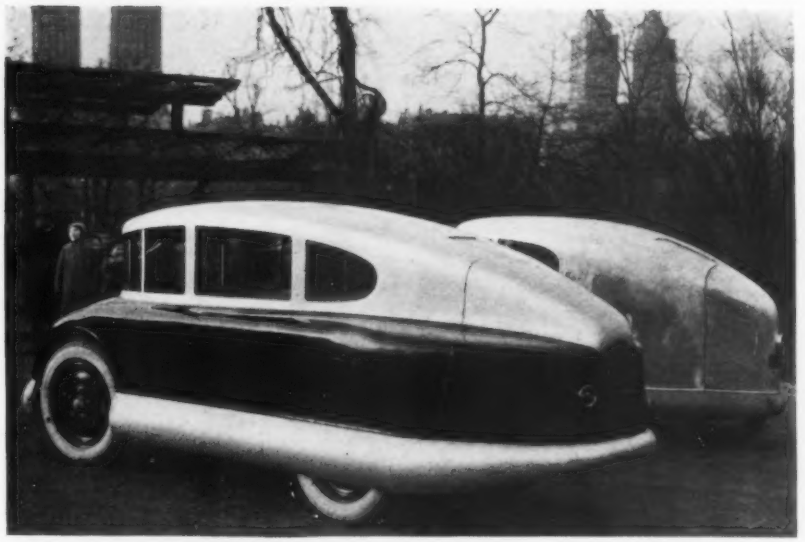
Special Louisiana La-Plant Choate 4-ton cane cart, capable of hauling double the loads hauled by four teams of mules. Body design permits load to be picked up with one sling; track-laying running gear prevents miring



Full-revolving Hughes-Keenan crane for mounting on Caterpillar tractors. The crane is so balanced that the standard 12-ft. boom at 45 deg. can lift 5,000 lb. 30 ft. per min. Two hand valves control the multi-cylinder hydraulic motor at the rear

Above—20-cu.yd. Western air-operated end dump car, equipped with 100,000-lb. trucks. The body dumps at 45 deg. by direct thrust of air cylinders, air being furnished by the locomotive, enough for one dump being stored in tanks at end. (Right)—A 60-in. power sweeper mounted on Clarkat Tructractor with speeds up to 7½ m.p.h.

in PRODUCT DEVELOPMENT



Streamline form and rear-mounted engines characterize these 85-in. wheelbase cars by James V. Martin. Wheels are independently sprung, bodies are of plywood, fabric and aluminum sheet. The smaller car is a 3-wheeler using a 7½-hp. Austin engine and chain drive, the larger a 4-cyl. engine, with worm gear and universal shafts

Rubber-Tired Rail Cars, Aluminum Hopper Cars, Air-Conditioned Diners

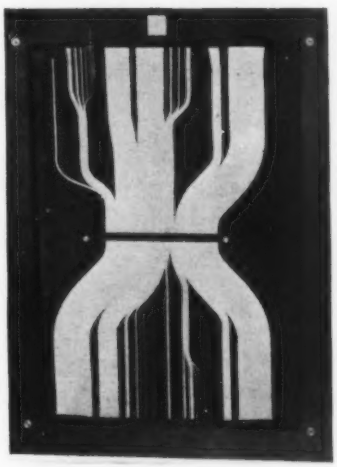
RUBBER-TIRED rail cars developed in France by Michelin & Cie., will be produced by E. G. Budd to compete with buses on short and swift hauls. The steel-flanged pneumatic tires fit standard-gage tracks, and adapted automobile engines will drive the cars at speeds up to 85 m.p.h. "Shotwelded" coaches of stainless steel will weigh 13,000 lb. instead of the conventional 140,000 . . . All-aluminum rail hopper cars being built by Canton Car will save 21,200 lb. in the 70-ton size, all parts being aluminum alloy except conventional steel trucks, brake gear, door mechanism, couplers, yokes, center plates, and safety appliances . . . Cost is increased about five times, wear about three, with weight reduced to less than two thirds . . . Spread of railway air-conditioning is indicated by Atchison, Topeka & Santa Fe's ten diners equipped with a system using engine steam for energy . . . Filters clean the air, after which it passes over coils heated or cooled as necessary . . . All equipment goes under the car roof . . . Battery-operated electric trains proved successful in demonstrations at Dublin, Ireland . . . Average speed 45 m.p.h., batteries being charged after each run.

Dutch Engineers Plan Huge Flying Boat With Oil Engines

Germany's Do-X, with its 157½-ft. wingspread, will soon be dwarfed by a Koolhoven (Dutch) flying boat twice its size . . . This monoplane will have 100-meter wingspread (about 382 ft.), with 1,000-sq. meter upper wing surface (about 10,764 sq.ft.) . . . Total flying weight 100 tons gives wing loading of almost 20 lb. per sq.ft.; total useful load 42 tons . . . Ten 1,000-hp. fuel-oil-type engines will burn 180 grams of fuel per hp.-hr. each, give 140 m.p.h. cruising speed, develop about 68 per cent of motor capacity, the surplus for take-offs and reserve . . . Materials will be light alloys and stainless steel . . . Passenger cabins and engines will be housed in wings, thus eliminating much of the fuselage . . . The plane will fly 3,200 miles non-stop, carrying over 200 passengers and two tons of freight.

Device Eliminates Carbon Paper—Clock Warns of Appointments

Engineers have again come to the aid of office workers . . . Clocks for warning of appointments, devices for quick construction of charts begged for by executives—and now two devices to eliminate messy carbon paper . . . One is the "Dupli-Typer," a simple metal frame holding a replaceable inked ribbon, that fits over typewriter platen to place inked ribbon between first sheet and "carbon" . . . More carbons may be made by using sub-frames and ribbons inked on both sides, every second carbon being typed on the back of a transparent sheet of paper . . . Another uses similar idea but more elaborate frame . . . Circular files have been designed during the past year or two to permit faster, more compact filing . . . First designed with their axes horizontal, newest type has its axis vertical and can be moved about on casters like a chair or coatrack.



The "Cosmograph," employing a group of paper strips set on edge and divided by spacers to graph any set of figures. Photostats are taken of finished settings, element designations being lettered thereon

Stainless Steel, Monel, Nickel, Rubber, in Process Equipment

More and more metal equipment enters process industries . . . Stainless steels, Monel metal, and now nickel-clad steels are used . . . New metal-clad piece dye tub uses nickel-clad steel with false bottom and front partition of pure nickel . . . Main and delivery reels are Monel metal, squeeze rolls are rubber . . . A metal cabinet resembling nothing so much as a spraying oven is being introduced for conditioning fabrics dried out too much in presses, driers, and calenders . . . Fabrics pass

through either in tension or in draped festoons, encountering currents of cool air saturated with water vapor . . . Festooning permits handling large volumes of goods in small space.

New Joints for Wood Add Strength; Wood Fiber Finds New Uses

Wood construction has always been considered inefficient due to joint weakness . . . During World War, with only wood available for construction, certain European countries developed newer, more efficient joints, now undergoing tests at Forest Products Laboratory . . . Metal and wood connectors or dowels strengthen joints four to ten times, make possible important economies in erection of structures, permit use of lower grades and species of wood for high-class construction . . . Sixty types now being tested; results to be announced early this year . . . Wood fiber, much used during War, now adapted to typewriter soundproofing pads and automobile muffler filling.

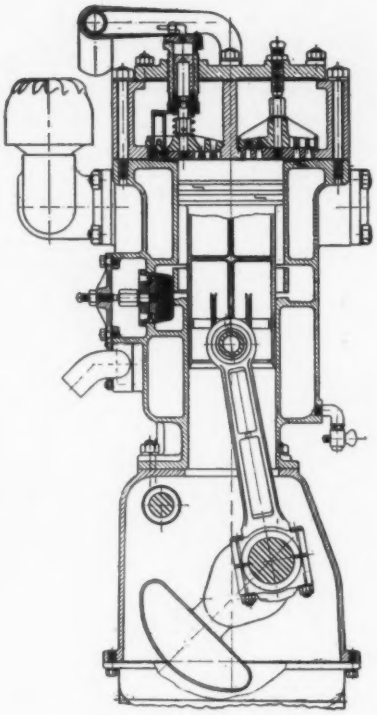
48 slots in the bezel about the face of this "Memo-Clock" provide spaces for appointment tabs at 15-min. intervals. Tab sets alarm to buzz at time of appointment

Turbines for Planes to Eliminate Exhaust, Noise, Vibration

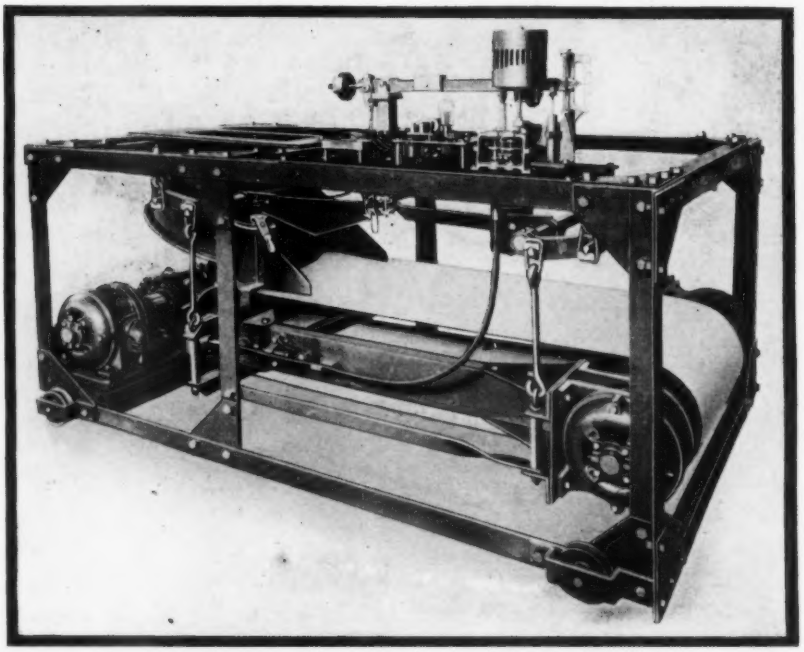
Steam turbines may drive airplanes yet, as Langley planned . . . Great Lakes Aircraft engineers are testing working models utilizing water-jacketed fuel-oil-fired boilers, used steam to be condensed in the wings . . . A single throttle controls both steam and oil supply . . . Advantages claimed are lessened fuel cost, fire hazards, lubricating oil cost . . . elimination of exhaust, noise, and vibration . . . Supercharging unnecessary; one central plant will supply power now provided by a nest of engines in large planes . . . Direct fuel injection, developed by Pratt & Whitney, will also reduce fuel cost and eliminate carburetors, pre-heaters and hot spots . . . Furnace oil can thus be burned successfully . . . Butterfly type air valve replaces carburetor and hot spot to permit "leaning" of mixture at high altitudes . . . Fuel injection pumps are arranged radially just in front of the usual valve tappets . . . Pumps are driven by four-lobe cam carried on forward face of the cylinder valve operating cam. The fuel is atomized as it enters cylinder by a hammer blow of the pump piston . . . Wright Field engineers have developed a new 30-lb. inertia starter, consisting of a standard starter with a booster magneto incorporated in the drive . . . Booster meshes with starter gears at same instant the starter engages with engine.

Home Entertainment Field Alive With Possibilities

"Home entertainment," new field for older radio stores and consequently radio engineers, continues forward strides . . . Alexanderson, of General Electric Lab, predicts localized television on light beam shortly . . . Range would be about 10 miles . . . Transmitter, mounted atop a high building, would send out arc-light waves . . . Photo-electric tubes in homes would pick up modulated waves and convert them into electrical waves, thus avoiding present distortion in transmission . . . *Radio Retailing* magazine predicts higher unit radio prices, principally consoles, new-purpose tubes, practical television, sound-on-film home movies, heightened auto-radio activity, popular short-wave sets, intensive demand for refrigerators, and other electrical appliances.



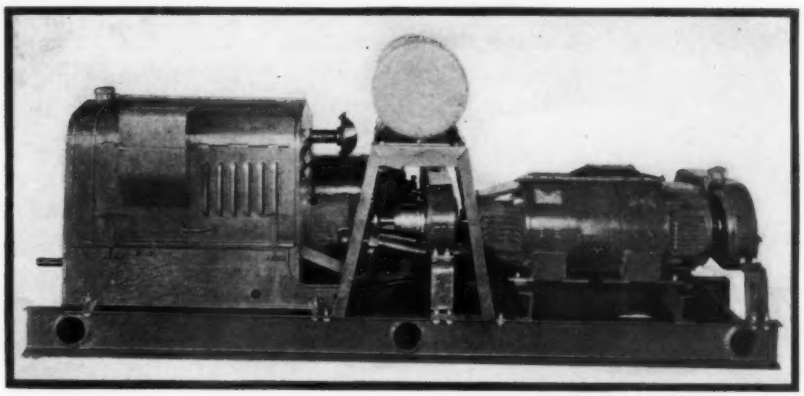
Rix supercharged air compressor raises free air capacity 25 per cent by trapping air with the trunk-type piston on the down stroke



A Burgess photo-electric integrator applied to this belt-conveyor scale is composed of a cell with an external slotted cylinder rotating at a fixed rate while a light is moved by the scale beam up and down to vary the point of cut-off of light impulses

One Refrigerator Shows Radical Changes—Many "Gadgets"

Refrigerating engineers have thus far thought in terms of the old family ice box, putting a mechanical cake of ice where the cake of real ice used to be . . . Now comes Potter refrigerator (preliminary mention, *PE*—Vol. 2, page 533), which has freezing unit completely insulated from food storage compartment, and producing a temperature of 10 deg. below zero for freezing ice cubes and frozen desserts . . . Temperature of 10 deg. above zero maintained automatically in adjacent cold storage compartment, while general food storage compartment, with separate chilling unit or coil, is maintained at 40 deg. above zero, moist cold . . . This avoids dehydration, de-frosting, and possible destructive chilling in too rapid cooling of food compartment when freezing desserts . . . Tiny electric lamp lights general food storage compartment . . . Other refrigerators exhibit trends toward "gadgets" indicated at the N. Y. Auto Show . . . One has combination door lock and bottle opener . . . Another an automatic door opener and a special egg basket to prevent disasters . . . Several incorporate ice cube trays that permit easy removal of cubes.



Portable beacon transmitter for use at aircraft landing fields. 10-hp. engine drives 500-watt motor through a flexible coupling and two 300-watt motors through chain drives to provide three needed frequencies

Several Diesel Developments Largely for Truck Engines

The trend toward diesels continues . . . A diesel-engined truck set a non-fueling record at Indianapolis Speedway, then went on to set non-stop endurance record . . . Bata, peerless Czechoslovakian shoe manufacturer, decided he wanted a huge, 8-wheeled truck to distribute shoes to his 1,800 retail stores . . . No builder could be found, so Bata made his own . . . 34 ft. long, 7½ ft. wide, 10 ft. high, equipped with a 6-cyl. 85-hp. diesel burning a gallon of crude oil each 7 miles . . . Capacity 7 metric tons at 25 m.p.h.; cuts two-thirds from Bata's transportation costs . . . Largest of European diesel plants just completed at Berlin for lighting and power . . . Two 11,000-hp. units can be speeded to 215 r.p.m., as compared with 94 obtained by giant diesel at Hamburg . . . Four mechanics run the entire plant, which cost $56 per kwh. to build.

Printing of Weight Ticket Coupled With Rapid Weighing

Printing a weight ticket normally interferes with rapid, accurate weighing . . . Toledo Scale, however, uses 4-oz. aluminum disk carrying raised weight-printing figures on face near rim . . . Twin platens, actuated by electric control button, squeeze ticket between type and printing ribbon when weight indicator comes to rest.

Composite Plug Ends Leaks In Tank Car Outlet Valve

Railway engineers have long been bothered by leakage about tank-car outlet valves . . . Now comes General American Tank Car Corp. with a tight-sealing valve, incorporating a plug composed of three tapered disks having two sheets of a new synthetic elastic packing material sandwiched between . . . Similar to rubber in physical characteristics, the material is unaffected by hydrocarbon oils . . . When plug is screwed tight against its seat, packing material squeezes out to form a tight seal, regardless of seat condition . . . Excessive compression is prevented because the metal valve disks themselves ultimately contact the tapered seat.

Room-by-Room Temperature Controls Devised

Room-by-room temperature controls, called Radiatherms, operate on thermostatic principle . . . regulate each radiator independently on a two-pipe system . . . Total temperature range is 35 to 80 deg. F., any temperature between these points being obtainable by setting . . . Valve seat and valve disk are Monel to prevent corrosion . . . Another similar unit has its thermostat away from the valve in the under-radiator air stream, to avoid metal-to-metal heat transfer.

Wide Variety in Electrical Devices Designed for Home Use

Electric chimes will supplant electric doorbells . . . providing a more pleasing note, different notes or combinations for front and back doors . . . and for those who still have maids, a maid-call, all in the same unit . . . New Rembrandt floor lamp incorporates reel for cord underneath base, taking up excess cord into concealed box . . . Proctor electric radiator incorporates telescoping, rust-proof drying rack for small articles . . . One water heater uses "percolator" arrangement to keep water circulating and at even heat, set by thermostat . . . Monel metal linings in ovens of new electric stove prevent staining. Switches are mounted behind a door for cleanliness . . . Tiny industrial motors are adapted to palm-fitting kitchen tools for mixing, beating, etc. . . . New clothes-washing units clamp right on stationary tubs . . . Most of them include only motor, agitator, and clamping device . . . One, the "Air-White," unusual in using the air pressure set up by an ordinary vacuum cleaner to produce bubbling action in star-shaped bubbler set at tub bottom to stir clothes and water . . . New "Lite-Saver" bulb incorporates winding to cut 110 volts to 6.2 for exit and similar constant-burning lights where high illumination is not required . . . 2-watt Neon bulb has been designed for night lights . . . Sodium vapor lamp invented in Germany, three to four times as efficient as ordinary lights, but light is in yellow portion of spectrum, thus giving effects similar to that of mercury-vapor lamps.

A New Beryllium Alloy

IT SHOULD BE good news that cast copper alloys with tensile strengths of 150,000 lb. per sq.in. and with Rockwell hardnesses above 100 are attainable in any plant having facilities for ordinary copper or bronze casting. Simply by adding to copper a small quantity of beryllium an alloy is produced which has greater strength and hardness than the original copper, and for many purposes is superior to the alloys of copper with tin or zinc. Alloys of beryllium and copper have been termed "beryllium bronze," though they do not really meet the definition of a bronze and are entirely different in physical characteristics.

Less than 10 years ago beryllium sold for $5,000 per lb.; it was unobtainable in large quantities even at that price. By continuous research, however, processes have been developed for more economical production of the metal until the price has been brought down to about $50 per lb. and a steady supply assured. A "master alloy," containing 12.5 per cent of beryllium, with the remainder copper, has now been placed on the market, so that any plant having facilities for casting copper or bronze can produce parts of beryllium bronze.

The Effect of Beryllium in Various Amounts

By the addition of 2 to 2.5 per cent of beryllium to copper a tensile strength of more than 200,000 lb. per sq.in. is obtainable in the wrought product with a Brinell hardness above 400. Tensile strengths well over 150,000 lb. per sq.in. have been obtained in cast parts. Alloys with a beryllium content as low as 1.25 per cent show remarkable resistance to abrasion. This amount of beryllium is the minimum content that will permit heat-treatment, but tensile strengths and hardnesses well above those of ordinary bronzes are shown even in the low-beryllium alloys. Alloys with as low as 0.2 per cent of beryllium are more readily machinable than copper, and the alloys with even small quantities of beryllium cast well and are very homogeneous because of the high deoxidizing power of beryllium. An important feature of the beryllium-copper alloys is that they combine high electrical conductivity with a high strength-weight ratio.

Beryllium is a white metal and because of the fact that its specific gravity is only about 70 per cent of that of aluminum the great volume per unit of weight gives it a powerful whitening effect on copper. A beryllium-copper alloy with only 2.5 per cent of beryllium has a yellowish color equivalent to that of a rich low brass. This whitening power, together with the homogeneity and great strength of the castings, should make the beryllium-copper alloys very suitable for hardware. The low specific gravity as compared with nickel, which is used for whitening bronze in the hardware industry, is also of advantage where light weight is important. The melting point of beryllium is somewhat above that of copper, and for that reason melting and casting are done at a slightly higher temperature than for brass or bronze of the usual compositions.

Suitable for Bearings

All of the beryllium-copper alloys give a crystalline structure very suitable for bearing metals, and tests made on bearings for German railways have indicated anti-friction and wearing qualities superior to those of tin bronzes.

Beryllium-copper alloys with about 2.5 per cent of beryllium are age-hardened by exposing them to a temperature of 575 deg. F. for about 3 hours. A hot-rolled annealed alloy containing 2.20 per cent of beryllium has a tensile strength of 75,000 lb. per sq.in., elongation of 50 per cent in 2 in., and a Rockwell B hardness of 60; when age-hardened it has a tensile strength of 154,000 lb. per sq.in., elongation of 8.5 per cent, and Rockwell B hardness of 105. This same alloy when hardened by cold rolling under a reduction of 50 per cent without heat-treatment or age-hardening has a tensile strength of 139,200 lb. per sq.in., elongation of 3 per cent, and Rockwell B hardness of 101. Rolling to a reduction of 90 per cent increased the tensile strength to 188,000 lb. per sq.in., and Rockwell hardness to 104.

Beryllium-copper alloys at the present time are more expensive than copper-tin bronzes, but their superior physical properties will make them economical for parts where corrosion resistance, wear resistance and high strength are important.

Oil Lubrication

1—Principles and some simple methods

A study of present practice in designing for adequate lubrication, and a brief description of the simpler types of lubricating methods and devices. More elaborate ones will be treated in coming numbers. This short series affords a means of checking your own practice and experience with those of others

By HERBERT CHASE
Consulting Engineer

IN ORDER that proper provisions may be made, lubrication must be considered when the design is in progress. Often castings should be cored for oil reservoirs or oil leads, or room should be left for oil seals. Perhaps the whole frame or housing of the machine should be designed to retain oil and to permit all wearing parts to be flooded with lubricant.

An ideal to be sought in bearing lubrication is the maintenance of a complete film between the shaft or journal and the bearing surface. Such a film is readily maintained in most cylindrical bearings if certain simple conditions are fulfilled. The ideal is to supply lubricant at a rate at least equal to that at which the lubricant leaks or is forced out of the bearing. Such a rate of feed is not always easily maintained without more expense than is justified, and in many cases it is not essential. The condition sometimes termed "boundry" lubrication, in which a partial film is maintained, is entirely adequate in many bearings, especially when the unit loading is light.

All cylindrical bearings require a clearance between the bearing surface and the journal. The amount usually recommended is approximately 0.001 in. per in. of shaft diameter, but even shafts as small as $\frac{3}{8}$ in. diameter are usually made 0.002 in. smaller than the bearing bore. Some authorities recommend giving a clearance of 0.002 in. plus 0.001 in. for each inch of shaft diameter. With complete film lubrication this clearance space is kept filled with oil.

When the journal rotates, its axis does not coincide with that of the bearing, but is slightly eccentric, taking a position relative to the direction of rotation, as shown in Fig. 1. Under ideal conditions, the film is complete, and there is no metal-to-metal contact. In consequence, the friction is only that between layers of the oil film, or true fluid friction, the coefficient of friction being 0.001 to 0.003, depending upon the lubricant.

Obviously the oil should be introduced to the bearing at or near the point of minimum pressure, and if any grooving is done, the grooves should be in the low pressure area, for if put in a high pressure area the oil will be forced out and the film destroyed. For bearings subjected to loading in one direction and in which complete film lubrication is to be maintained, grooves should be usually only axial. Their only purpose is to make sure that the ends of the bearings do not run dry and to distribute the oil film with reasonable uniformity. In large slow-speed bearings, leakage may tend to starve the pressure area. For such a condition a longitudinal groove is sometimes cut from 30 to 40 deg. in advance of the area of greatest pressure to enable some of the oil near the ends

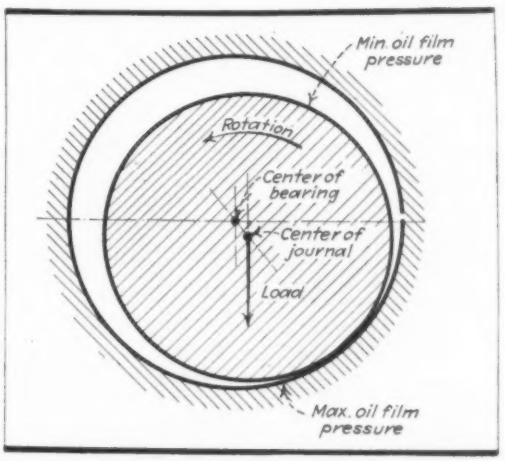


Fig. 1—Showing the location of maximum and minimum oil film pressures, relative to the direction of rotation and the load

to return to the center of the bearing. Shaft deflection is also a large factor in controlling pressure distribution in a long bearing, as rubbing is likely to occur and cause hot spots at the ends. Shortening the bearing avoids this trouble but decreases unit capacity, thus making a compromise necessary.

Accurate machine work is essential in bearings. Ridges only 0.0005 in. high are likely to establish

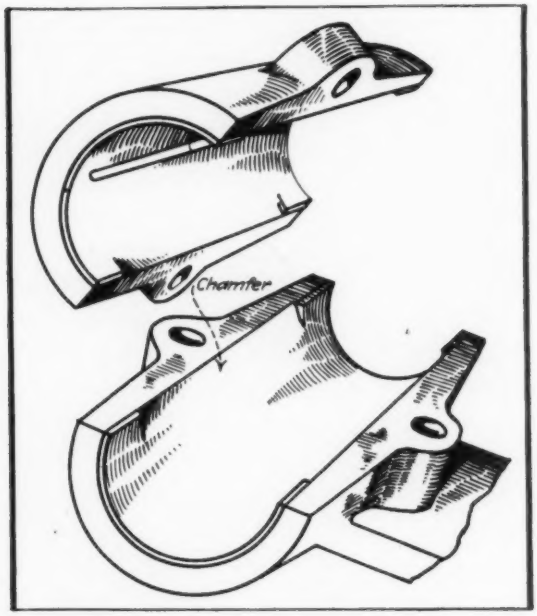


Fig. 2—Correct grooving and chamfering for a horizontal split bearing carrying a downward load. For slow speed and extremely heavy pressure, a longitudinal groove is sometimes added just at the beginning of the pressure area in the lower half

metallic contact and cause serious trouble. Sharp edges between the halves of a bearing or at oil grooves are likely to disrupt the oil film and should always be avoided by providing an adequate chamfer or beveled edge. Neither grooves nor chamfers should extend to the ends of a bearing, however, as in that case the oil is likely to leak from the ends of the bearing without entering the high pressure area.

When an "all-loss" system of feed is suitable, excellent results are obtained with individual mechanical lubricators or some centralized system of similar form. But the oil supply must be closely regulated to the requirements of the bearing and probably adjusted as the bearing wears. Otherwise oil will be wasted or the bearings may not receive oil at the proper rate. Such lubricators, in addition to being positive in operation, so long as they are kept supplied with oil, have the advantage of starting and stopping with the machine, and usually give visual indication of correct functioning. On the other hand, they require manual filling, and usually quite a bit of piping, which, unless the system is very neatly designed into the machine, may be somewhat unsightly and subject to injury or breakage. In some cases the expense and complication of mechanical lubricators and of their installation are serious drawbacks, but when rightly applied and used these lubricators produce excellent results.

When the design of a machine permits and other conditions are favorable, flange, ring or chain oilers can be built in. They must be designed as a part of the bearing, however, and involve the use of a reservoir which should have as large a capacity as possible and should be arranged for ready filling and cleaning. A gage or window for observing the oil level is desirable.

Ring oilers are widely used on electric motors and generators and on moderately high-speed shafting of two-inch or larger diameters. They are applied also in some cases on small steam turbines as well as on other steam and internal combustion engines. The advantages of ring oilers include: (1) A relatively constant and uniform supply of oil so long as the correct oil level is maintained. (2) Little attention is required. (3) Relative cleanliness if proper provision is made to minimize leakage at bearing ends. (4) The simple ring is the only mechanism involved and the oiling system is self-contained. (5) High economy in lubricant. (6) If oil reservoir is correctly proportioned, foreign matter settles out and lubricant helps to dissipate heat. (7) Within limits, the oil feed increases and decreases with the speed.

Since the ring which feeds the oil is driven by friction, the supply of oil is not positive. Flow of oil into the bearing is by gravity, hence the film pressure at the point at which the oil is applied must not exceed the very small gravity head available, as otherwise the oil will not enter. Appli-

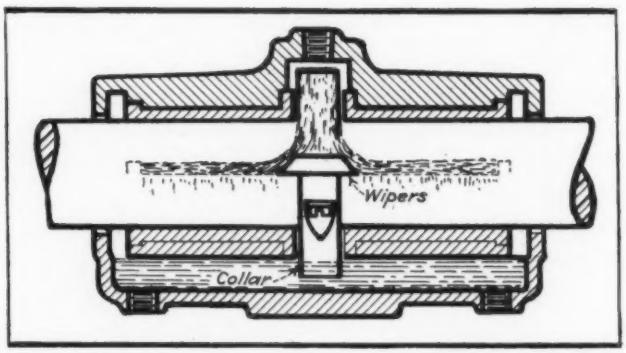


Fig. 3—Collar-oiled bearing, showing how wipers deflect the oil into longitudinal channels

cations are usually confined to bearings in which the load is downward and the bearing is in a substantially horizontal position. To assure regular rotation of the ring, it must be in continuous contact with the shaft and with sufficient force to assure rotation. For these reasons, operation on shafts of less than two-inch diameter may not prove satisfactory. Vibration or a jarring, causing the ring to jump, may also interfere with satisfactory operation. Again, if the peripheral speed of the shaft is too high, the ring may slip to such an extent that the quantity of oil delivered is not adequate to maintain a complete film, or the centrifugal force may be sufficient to throw the oil off the ring. Too high a speed may also result in churning and frothing of the oil.

Rings are usually made of a diameter twice

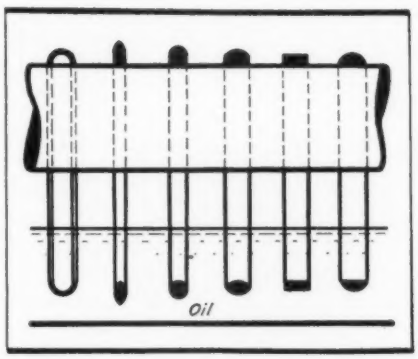


Fig. 4—Oil rings of various cross sections, arranged in order of ring speed for a given shaft speed. Increased contact with the shaft and decreased resistance to passing through the oil, increases ring speed. For high-speed shafts, the forms to the left should be used

that of the shaft and the oil level is maintained about half the shaft diameter below the bottom of the shaft. One ring is recommended for bearings up to 8 in. in length, two for bearings 8 to 16 in. long, and three for still longer bearings. Rings should be true and smooth, as otherwise they are likely to stick or cause spray. Rings with a plain cylindrical inner surface afford the greatest contact with the shaft and are therefore likely to turn faster than those having a contact surface of any other form. Rings of trough and other sections have been used. For very slow speeds neither a ring nor a chain may prove satisfactory.

Scrapers or other means of deflecting the oil from the ring into the bearing are sometimes employed, or the edge of the bearing shell at the ends of the slot made to receive the ring may be beveled to serve this purpose. A well-chamfered groove on the "on" side of the bearing, and extending longitudinally to within $\frac{1}{2}$ in. of the ends of the bearing, is one method. If the shaft reverses, such a groove should be made at each side.

Chain oilers are similar in construction and operation to ring oilers. The arc of contact with the shaft being greater than that of a ring, they rotate with less slip. Should a chain link break, however, the supply fails. Chains are well suited for large slow-moving shafts and can feed from a lower level than rings.

Much the same information relating to ring oilers applies also to collars or flanges fixed to the shaft and arranged to dip in a reservoir of oil below the bearing. Such a device lifts the oil above the bearing, whence, if properly deflected, it finds its way into the bearing. Being fixed to the shaft, the collar has positive rotation.

Fixed collar oilers are usually placed in the center of the bearing, which consequently is split at right angles to the shaft, but collars can be made to operate at one end of the bearing if correctly proportioned and provided with a scraper for deflecting the oil to the point of feed to the bearing. When a collar is placed in the center of the bearing, the scraper is usually arranged to collect oil from both faces of the collar and may have troughs, or deflect oil into troughs that distribute the oil longitudinally along the bearing. In other instances the oil is deflected to only one point on the bearing, whence, as in ring-oiled bearings, it is distributed by a longitudinal groove or grooves.

A flange, in effect the same as a fixed collar, may be used in place of a collar. Or any disk-shaped member of a machine, such as a flywheel or gear can be used to lift oil from a reservoir. It is necessary, of course, to make provision for collecting the oil thrown or scraped from such a member and for conveying it by gravity to the bearings served. Such a system was used with reasonable success for lubricating the bearings on the model T Ford and some other automotive engines.

Some machines, especially those having cranks, can be effectively lubricated by splash systems. If the level of the oil is maintained within safe limits and means for collecting the lubricant and distributing it to bearings are properly designed, a rate of feed sufficient to maintain complete film lubrication is usually possible. The limitations of such a system are similar to those in which a flange or flywheel is used to feed oil, and splash systems are sometimes combined with or supplemented by such systems. As is true for all circulating systems, settling sumps and other means for collecting and removing foreign matter, including any water that may enter the system, are highly desirable, if not essential, to long-continued operation.

Here is the second of three articles on clutches and brakes. In December the author covered heat-radiating capacity, this time he gives formulas and methods for determining the unit pressures of engagement under normal conditions. In the third article, to appear shortly, he will present the equations for calculating unit pressures when a dropping load is brought suddenly to a standstill

Engagement Pressures in Band Clutches and Brakes

By A. G. RASMUSSEN
Mechanical Engineer, Indianapolis, Ind.

IN BAND clutches or brakes, a flexible steel band lined with friction material is wrapped around a metal drum and arrangements made so that the steel band can be contracted, with the result that the two elements revolve or tend to revolve together through the friction of engagement. The common type of construction of a band clutch includes a friction drum mounted to revolve freely on a power-driven shaft and a driving member keyed to the shaft, this driving member carrying the friction band and the lever arrangement used to produce the contraction of the band on the friction drum. In a band brake, the band and lever arrangement producing the contraction of the band is supported from the stationary side frame of the structure.

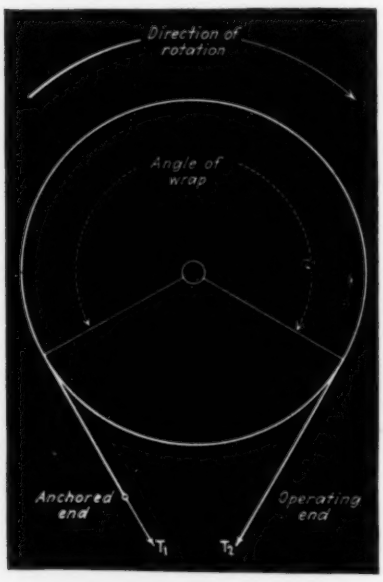


Fig. 1—Typical arrangement of band for clutch or brake with rotation in the direction from the anchored end to operating end

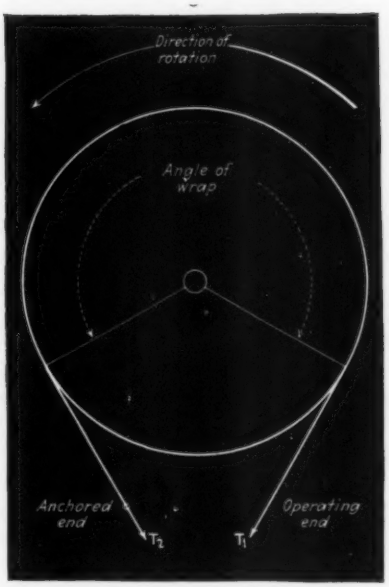


Fig. 2—Reverse arrangement of that shown in Fig. 1. Rotation is in the direction from the operating end to the anchored end

Band clutches or brakes of this type are self-energizing in that tension in the band produces a positive contact pressure against the drum. The frictional force at any point tends to increase the tension in the band just beyond that point of contact. Thus, continuing around the band to the point where the engagement of the band on the drum ends, the tension in the band is continually increasing, progressively producing a greater pressure of contact and therefore a greater frictional force. The rate of increase of the tension in the band is an exponential function, and the relation of the tension in the end of greater tension to that

Table I—Values of Y

uk	y	$\log y$	uk	y	$\log y$
0.01	1.065	0.0272876	0.46	17.998	1.2552296
0.02	1.134	0.0545752	0.47	19.165	1.2825172
0.03	1.207	0.0818628	0.48	20.408	1.3098048
0.04	1.286	0.1091504	0.49	21.732	1.3370924
0.05	1.369	0.1364380	0.50	23.141	1.3643800
0.06	1.458	0.1637256	0.51	24.642	1.3916676
0.07	1.552	0.1910132	0.52	26.239	1.4189552
0.08	1.653	0.2183008	0.53	27.941	1.4462428
0.09	1.760	0.2455884	0.54	29.753	1.4735304
0.10	1.875	0.2728760	0.55	31.682	1.5008180
0.11	1.996	0.3001636	0.56	33.737	1.5281056
0.12	2.126	0.3274512	0.57	35.925	1.5553932
0.13	2.263	0.3547388	0.58	38.254	1.5826808
0.14	2.410	0.3820264	0.59	40.735	1.6099684
0.15	2.566	0.4093140	0.60	43.377	1.6372560
0.16	2.733	0.4366016	0.62	49.185	1.6918312
0.17	2.910	0.4638892	0.64	55.771	1.7464064
0.18	3.099	0.4911768	0.66	63.239	1.8009816
0.19	3.300	0.5184644	0.68	71.706	1.8555568
0.20	3.514	0.5457520	0.70	81.308	1.9101320
0.21	3.741	0.5730396	0.72	92.195	1.9647072
0.22	3.984	0.6003272	0.74	104.54	2.0192824
0.23	4.242	0.6276148	0.76	118.54	2.0738576
0.24	4.518	0.6549024	0.78	134.41	2.1284328
0.25	4.811	0.6821900	0.80	152.41	2.1830080
0.26	5.122	0.7094776	0.82	172.82	2.2375832
0.27	5.455	0.7367652	0.84	195.96	2.2921584
0.28	5.808	0.7640528	0.86	222.19	2.3467336
0.29	6.185	0.7913404	0.88	251.95	2.4013088
0.30	6.586	0.8186280	0.90	285.68	2.4558840
0.31	7.013	0.8459156	0.92	323.94	2.5104592
0.32	7.468	0.8732032	0.94	367.31	2.5650344
0.33	7.952	0.9004908	0.96	416.49	2.6196096
0.34	8.468	0.9277784	0.98	472.26	2.6741848
0.35	9.017	0.9550660	1.00	535.50	2.7287600
0.36	9.602	0.9823536	1.05	733.16	2.8651980
0.37	10.225	1.0096412	1.10	1003.8	3.0016360
0.38	10.888	1.0369288	1.15	1374.3	3.1380740
0.39	11.594	1.0642164	1.20	1881.5	3.2745120
0.40	12.345	1.0915040	1.25	2576.0	3.4109500
0.41	13.146	1.1187916	1.30	3526.9	3.5473880
0.42	13.998	1.1460792	1.35	4828.7	3.6838260
0.43	14.906	1.1733668	1.40	6610.9	3.8202640
0.44	15.873	1.2006544	1.45	9051.1	3.9567020
0.45	16.902	1.2279420	1.50	12392.0	4.0931400

in the end of lesser tension is shown by the following equation:

Let T_1 = the final or greater tension in the band.

T_2 = the initial or lesser tension in the band.

e = base of natural logarithms.

u = coefficient of friction.

θ = angle of contact or wrap measured in radians.

k = extent of wrap = fractional part of a full circular contact.

Then
$$\frac{T_1}{T_2} = e^{u\theta} \tag{1}$$

It is more convenient to use logarithms to the base 10. Also it is more convenient to reduce θ which is measured in radians, to k, which is the fractional extent of wrap.

$$k = \frac{\text{angle of wrap}}{360^0} \tag{2}$$

$$\theta = 2\pi k$$

$$\frac{T_1}{T_2} = 10^{0.43429\ u\theta}$$

$$= 10^{0.43429\ u2\pi k}$$

$$= 10^{2.72876\ uk}$$

$$\frac{T_1}{T_2} = \text{antilog } 2.72876\ uk \tag{3}$$

Let values of
$$\frac{T_1}{T_2} = y \tag{4}$$

Values of y for various values of uk are given in Table I.

Since
$$T_1 - T_2 = R \text{ (the rim force)} \tag{5}$$

$$T_1 = R\frac{y}{y-1} \text{ lb.} \tag{6}$$

and
$$T_2 = R\frac{1}{y-1} \text{ lb.} \tag{7}$$

Let values of
$$\frac{y}{y-1} = Y \tag{8}$$

Therefore
$$T_1 = R\ Y \text{ lb.} \tag{9}$$

and
$$T_2 = R\ (Y - 1) \text{ lb.} \tag{10}$$

Values of Y for various values of uk are given in Table II.

Table II—Values of Y

uk	Y	uk	Y	uk	Y
0.01	16.420	0.31	1.166	0.62	1.021
0.02	8.468	0.32	1.155	0.64	1.018
0.03	5.822	0.33	1.144	0.66	1.016
0.04	4.500	0.34	1.134	0.68	1.014
0.05	3.709	0.35	1.125	0.70	1.012
0.06	3.184	0.36	1.116	0.72	1.011
0.07	2.810	0.37	1.108	0.74	1.010
0.08	2.531	0.38	1.101	0.76	1.009
0.09	2.315	0.39	1.094	0.78	1.008
0.10	2.144	0.40	1.088	0.80	1.007
0.11	2.004	0.41	1.082	0.82	1.006
0.12	1.889	0.42	1.077	0.84	1.005
0.13	1.792	0.43	1.072	0.86	1.005
0.14	1.709	0.44	1.067	0.88	1.004
0.15	1.640	0.45	1.063	0.90	1.004
0.16	1.579	0.46	1.059	0.92	1.003
0.17	1.524	0.47	1.055	0.94	1.003
0.18	1.477	0.48	1.052	0.96	1.002
0.19	1.435	0.49	1.048	0.98	1.002
0.20	1.398	0.50	1.045	1.00	1.002
0.21	1.365	0.51	1.042	1.05	1.001
0.22	1.335	0.52	1.040	1.10	1.001
0.23	1.308	0.53	1.037	1.15	1.001
0.24	1.284	0.54	1.035	1.20	1.001
0.25	1.262	0.55	1.033	1.25	1.000
0.26	1.243	0.56	1.031	1.30	1.000
0.27	1.225	0.57	1.029	1.35	1.000
0.28	1.208	0.58	1.027	1.40	1.000
0.29	1.193	0.59	1.025	1.45	1.000
0.30	1.179	0.60	1.024	1.50	1.000

In some cases, the drum will rotate in the direction opposite to that shown in Fig. 1. If the arrangement is as shown in Fig. 2, the anchored end is the end of lesser tension T_2 and the operating end is the end of greater tension T_1. The operating end lever arrangement must be such that sufficient tension T_1 can be produced to effect proper braking. In some instances, where the load to be handled in this reverse direction is small, an otherwise excessively powerful system of levers is avoided by this arrangement.

Differential brakes are often used on large, powerful hoists. Their arrangement is shown by Fig. 3. The end of greater tension T_1 is secured to the operating lever at the lesser radius a and assists in producing the initial tension T_2, effective at radius b.

$$Pr + T_1 a = T_2 b \tag{11}$$

$$Pr = T_2 b - T_1 a$$

$$= R\,b\,\frac{1}{y-1} - R\,a\,\frac{y}{y-1}$$

$$= R\left(\frac{b}{y-1} - \frac{ay}{y-1}\right)$$

$$P = \frac{R}{r}\left(\frac{b-ay}{y-1}\right) \tag{12}$$

It is seen that if $ay = b$, then $P = O$, a condition indicating that no force is required to produce continuing braking action after it has once started. Such a brake is dangerous in that it will automatically lock with ever increasing force until motion ceases or something breaks. However, this feature is desired in some brakes which are designed to prevent rotation in one direction as, for instance, antibacking brakes.

The following equations which are used in the working out of a design are repeated here for convenience.

Rim force	$R = T_1 - T_2$	(5)
Maximum tension	$T_1 = R\ Y$ lb.	(9)
Minimum tension	$T_2 = R\ (Y-1)$ lb.	(10)

The maximum pressure of engagement occurs at the end of maximum tension. This pressure may be calculated to determine if it is excessive for the lining. The maximum unit pressure of engagement p_1 is found as follows:

b = width of band in inches
d = diameter of friction drum in inches

$$p_1 = \frac{2T_1}{bd} \text{ lb. per sq. in.} \tag{13}$$

The minimum unit pressure of engagement p_2 is found as follows:

$$p_2 = \frac{2T_2}{bd} \text{ lb. per sq. in.} \tag{14}$$

It should be noted that $\frac{p_1}{p_2} = y$, therefore $p_2 = \frac{p_1}{y}$ the value of y being obtained from Table I for the value of uk.

The above values of T_1, T_2 and p_1, p_2 are the values of the total tension at each end and the corresponding pressures of engagement at each end respectively. It may be desired to know the pressure of engagement at some intermediate point or at several intermediate points.

Call p' the pressure of engagement at θ degrees from the end of maximum tension.

$$\frac{p_1}{p'} = y'$$

or

$$p' = \frac{p_1}{y'} \tag{15}$$

For a second intermediate point,

$$p'' = \frac{p_1}{y''}$$

It may be desired to obtain the pressures at the one-quarter point, mid-point, and three-quarter point. Since the extent of wrap for the full contact is k, therefore the extent of wrap for the quarter-point $= \frac{k}{4}$, mid-point $= \frac{k}{2}$, and the

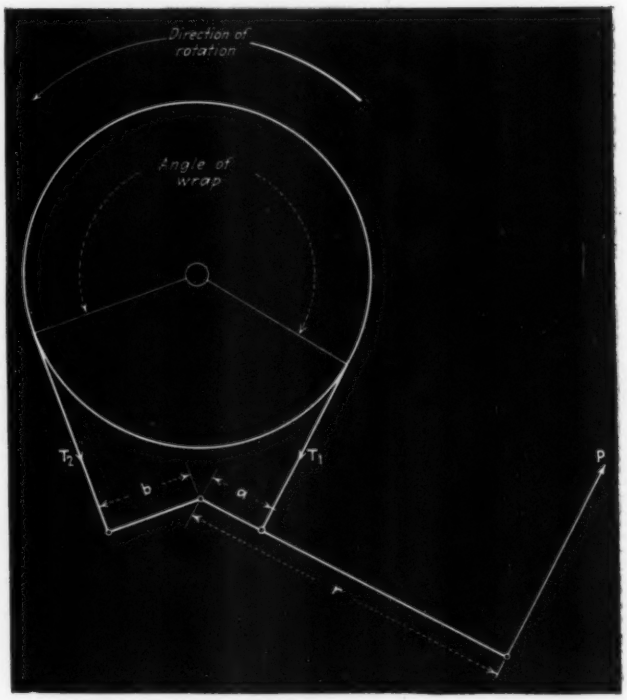


Fig. 3—Typical arrangement of a differential band clutch or band brake

wrap for the three-quarter-point $= \frac{3k}{4}$.

Call the proper value of y for the quarter-point y', then the log of y for the mid-point is 2 log y', for the three-quarter-point 3 log y' and for the end point it is 4 log y'.

The foregoing explanation is given mainly to show the particular characteristic of the exponential equation, namely, that the value of y for any point is the square of the value of y for the point lying mid-way. Similarly the value of y at any point is the cube of the value of y at the one-third point.

Example: To find unit pressures at intermediate points.

Assume 24 in. diameter brake drum, 3 in. width of lining. Angle of wrap=330 deg. Rim force, R=5,000 lb. Assuming u=0.55, then uk=0.55 ×11/12=0.50. For this value of uk, the value of Y from Table II is found to be 1.045.

From Equations (9) and (10)

$$T_1 = 5{,}000 \times 1.045 = 5{,}225 \text{ lb.}$$
$$T_2 = 5{,}000 \times 0.045 = 225 \text{ lb.}$$

From Equations (13) and (14)

$$p_1 = \frac{2 \times 5225}{3 \times 24} = 145 \text{ lb.}$$
$$p_2 = \frac{2 \times 225}{3 \times 24} = 6.25 \text{ lb.}$$

For the one-quarter point, uk=0.125, for the mid-point, uk=0.25 and for the three-quarter point, uk=0.375. The corresponding values of y are 2.194, 4.811, and 10.556 respectively.

For the quarter point

$$p = \frac{145}{2.194} = 66 \text{ lb.}$$

For the mid-point

$$p = \frac{145}{4.811} = 30 \text{ lb.}$$

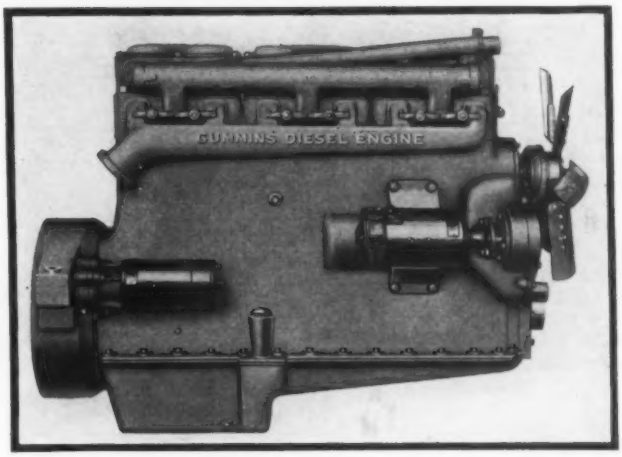
For the three-quarter point.

$$p = \frac{145}{10.556} = 13.7 \text{ lb.}$$

In a similar manner, the unit pressures of engagement at any intermediate points can be calculated.

The unit pressures of engagement as given in the foregoing equations do not hold true for band brakes used on hoists where the load is dropped the greater part of the distance and is caught at the lower end of the travel and brought to a standstill with a hard application of the brake. Under such conditions, the unit pressures are increased considerably. The analysis for determining approximately what these abnormal pressures might be, is based on the kinetic energy to be absorbed.

Diesel-Powered Truck Sets Endurance Record



Trim appearance—another proof of good design

NEWSPAPERS during Christmas week, loaded with holiday items, recorded in obscure paragraphs the record-breaking run of the Cummins diesel truck non-stop run at Indianapolis Speedway. Performance figures show that the truck covered a total of 14,600 miles at an average speed of 43.397 m.p.h., at a total fuel cost of $71.54. It ran 10,005 miles without refueling, 13,535 miles in 308½ hours without a truck stop, while the engine ran 336 hours without a stop. Top speed of the truck was 65 m.p.h., and the last lap averaged nearly 50 m.p.h. At the end of the run both truck and engine were still in good running condition.

The 125-hp. engine has 6 cylinders with 4⅞-in. bore by 6-in. stroke. Speed is 1,800 r.p.m. No fan was used, a standard radiator for a 75-hp. gasoline engine being used, with more than two-thirds of it covered. Maximum cooling water temperature was 125 deg. F. Unusual design features include completely dustproof enclosure coupled with good accessibility, complete pressure lubrication, removable machine-honed cylinder liners, interchangeable main bearing shells, built-in air compressor, 400-1,200 watt generator capacity, 7-bearing crankshaft. All accessories are gear-driven and are removable as units. The engine bare weighs, 1,850 lb. This weight and the engine dimensions are comparable to gasoline engines of equivalent power and uses. One advantage of the diesel is its much smaller fuel consumption, resulting in lighter fuel weight under ordinary conditions. Fuel consumption on the run averaged ten miles to the gallon, high because of a reserve tank leak.

EDITORIALS

KENNETH H. CONDIT
Editor

Basic Knowledge Before Specialization

ENGINEERS are confronted with something akin to a paradox. This is, we are told, the age of specialization, yet a broad understanding of general engineering principles was never so necessary. Every engineer must know the fundamentals of electricity since motors, controls, relays and magnets are found in all classes of machines. He should know enough of chemistry to be able to select the proper plastic material for certain duties and enough metallurgy to use the right metal under severe conditions.

Product engineers must be far more than designers of mechanisms no matter how ingenious these may be. The successful engineer must not only visualize the operation of the completed machine, but he must consider strength, machineability and the other factors of the materials he uses. Fundamentals of many branches of engineering are a necessary part of his training.

■

Time for Sportsmanship

In a recent address an executive of a prominent company declared that now is the time for sportsmanship in business. He particularly called for fair play and the absence of plagiarism in product development. With only a relatively few well designed products getting recognition in the way of increased sales, the temptation is to grab some of this lucrative business by copying. There is a truism going around that anybody can make a worse product to sell at a cheaper price. It's a cheap trick. Imitation is, after all, the worst form of destructive competition.

Sportsmanship is called for because legal redress is long drawn out, expensive and not always satisfactory. While not attempting to deprecate the value of a good patent, unfortunately it is only valuable because it has withstood the siege of litigation. The copier is the last to benefit if eventually he must surrender his profits, but because of human greed for a temporary gain, he often chances the future.

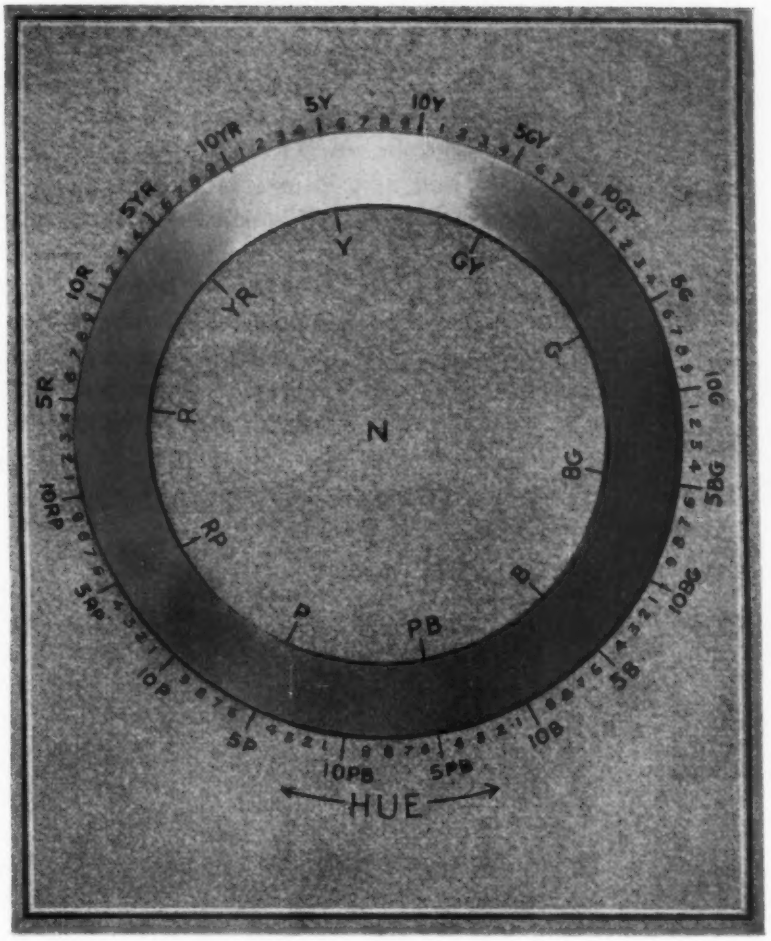
It is not always necessary to have a new idea. Old ideas may be applied in a new way, a new use may be found for an old idea, faults eliminated through a study of complaint correspondence, the product may be "styled," given a new package, a new size, or a new price. There are so many ways of finding a way out, that it should never be necessary to resort to copying to gain a market. Pressure in this direction coming from the sales department should be resisted to the last ditch. Professional pride and ethics forbid stealing ideas, one's own self-respect condemns it.

■

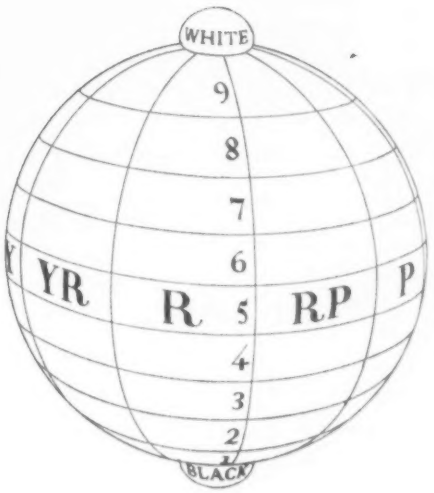
The Sad Tale of a Horn Button

Not many years ago the engineers of a certain high-priced and justly famous automobile were making a number of detail improvements in the design of the car. Among other items was a new horn button. An extremely attractive and ingenious unit was developed, which included a molded plug for the business part of the device. Special dies were called for because the new button differed from the one that had been used. As the cars were made in relatively small lots, the die cost per car amounted to eleven dollars, a very minor item in the total cost, but nevertheless one that caught the eye of the president when the proposed changes were up for approval.

Eleven dollars for a button about the size of a lead pencil eraser was more than he could accept with equanimity, so he set his purchasing agent the task of finding an equivalent standard unit that could be bought in the market. The catalog of a big electrical novelty house showed a variety of such buttons one of which was entirely suitable for the purpose. It cost twelve cents. The other ten dollars and eighty-eight cents was applied to profit and the engineers were informed that although quality was the primary consideration in the product of the company there was a virtue in tempering pride of authorship with a strong dash of common sense.



HUE is measured by letters and numbers placed clockwise around the color sphere. Value or degree of light strength, ranges in ten steps from black to white on the axis of the color sphere. This classification was worked out by the Munsell Color System and we are enabled to present it here through the courtesy of the Universal Color Standards, Inc., and by special permission of the copyright owners



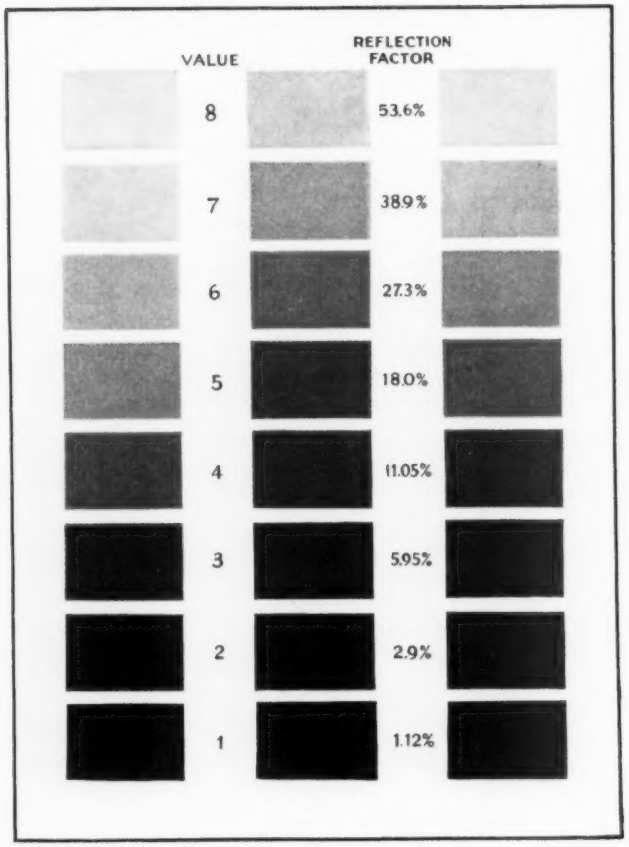
What IS Color?

Even though the engineer may feel that he must turn to the artist or color consultant for help when he has to make decisions on appearance or finish, he will be able to act more intelligently if he speaks the scientific language of color, or at least comprehends it. The system discussed here takes color out of the field of emotion and into the realm of fact. Following this article will come others dealing with practical applications

CONSCIOUSLY or unconsciously the prospective purchaser of any product has a feeling of satisfaction or of annoyance when his eye takes in its finish. Entirely apart from the impression given him by its form or workmanship, its color alone can arouse either one of these two opposite feelings, for color is an elusive but potent power. Color can make or break the sale of any product you may design.

There is even a close kinship between the effect of color combinations as seen on a product and those of musical rhythms as heard by the ear. Just as the fall of musical impulses can make the listener gay or sad, so can color groups, acting through the eye, convey pleasure or pain. Only very lately has this fact become recognized by many engineers, but it is one of the factors of design that must be considered, especially where the product is to be sold to the general public.

Color balance is a complicated problem—in fact, an art. Again taking the well-known subject of music for analogy, it can be said that it is not possible to compose music merely by following the written scale and intervals, but it is possible by systematic study of the laws and measurements of music for a layman to judge and distinguish be-



WHEN machines and equipment are to go into shops or offices requiring maximum light, the engineer who specifies the colors must consider their reflective factors

tween good and bad music. Likewise, it ought to be possible by systematic study for any average engineer to develop such a knowledge of color that he can apply it to his product pleasingly and in balanced proportions.

Any real progress in color selection must come by study into the laws that govern it. In this article it is not intended to set up rules by which correct colors are applied to any particular product, because that is more a function of the sales psychology of the particular product and the style of the moment; it is intended to describe an orderly system by which a correct comprehension of color significance can be obtained and the colors judged, matched and classified. With such definite color standards it is easier for the engineer to work with colors intelligently, and to understand the jargon of the consulting colorist or artist.

Intuition, Conjecture and Theory

Formerly, the use of color was based on intuitive sense, conjecture and theory, and there is still too much tendency to seek shelter in "feeling and inspiration," which in reality have nothing to do with the simple facts of vision and quantity. In the first place there was no accurate measurement of color or means of describing it. Correct thinking along color lines was beclouded by the irrelevant theory of the so-called "red-yellow-blue pigment primaries," which were erroneously considered to be a practical method of color measurement and description. It was not until the late Albert H. Munsell worked out and demonstrated visually the three dimensions of color—Hue, Value and Chroma—that it was possible to make real progress. Fortunately, just prior to this, various measuring instruments were developed which made it possible to choose and arrange the colors in intervals that formed standardized visual steps of the three dimensions.

The Three Dimensions of Color

Color has three dimensions: hue, which is the quality by which one color is distinguished from another; value, the quality by which a light color is distinguished from a dark one; and chroma, which is the quality by which is distinguished a strong color from a weak one. These three dimensions describe any color as easily as the three dimensions of length, breadth, and thickness describe a box. Each of these dimensions can be measured visually with practice as easily as other physical dimensions can be measured visually. The omission of any one of these three attributes leaves a doubt as to the character of a color, just as the character of a box would remain undefined if the length or one other dimension were omitted.

The white light of sunlight is composed of all the spectrally pure colors so balanced in combination that no one color is dominant, with a resulting pure white light. It was Sir Isaac Newton who first proved this by breaking up a beam of sunlight into its various wave lengths by means of a prism and producing an artificial rainbow on the wall. Passing a ray of sunlight through a prism breaks up the light into a band, or spectrum, of its component colors, red, yellow, green, blue. The common or distinguishing name of a color of the spectrum indicates its Hue. Any red is red in hue, and any blue is blue in hue. Thus, hue is the first characteristic of a color that the eye detects. In notating a color, its hue is indicated by the initial letter or letters of the color referred to—*R* for red, *Y* for yellow, *YR* for yellow red.

Between white, which is so light that no color (Hue or Chroma) can be seen in it, and black, which is so black that no color can be seen in it, the eye can distinguish various degrees of light strength ranging from light gray to very dark gray. Colors can be seen at these various intermediate levels of light strength, and this variable light strength (spaced in regular visual intervals)

is called Value. The unaided eye can distinguish readily ten different steps of value, and if these steps are graduated from black to white it is not difficult to estimate with the eye the approximate value of any color in terms of a number on the scale. Such a number merely indicates how light or dark a color may be. For example, a red of a lightness half way (visually) between black and white would be at the fifth level of value and would be indicated as R 5/.

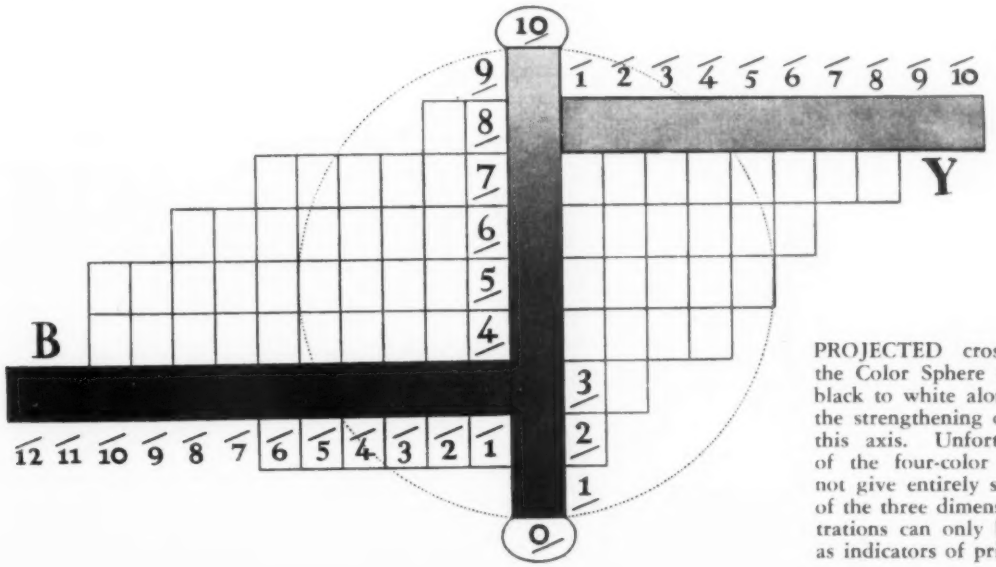
Two colors may be the same in hue and in value and yet be different in color strength. This difference is in the dimension of Chroma by which the degree of color strength or departure from gray is indicated. For instance, a red may be a strong red or it may be a weak, grayish red. A step in chroma is the unit of measure of change (in a single hue) between neutral gray and the maximum chroma, or intensity, obtainable in any hue at any given level of value. The steps are numbered outward from *N*, the neutral axis, toward the maximum chroma. As an example, a red midway between white and black, and five steps out in chroma, would be written R5/5. The strongest possible chroma obtainable in practically nonfading color materials varies with different hues and at different levels of value. Yellow, for instance, which is strongest only when it is light, can be divided into more distinguishable steps of chroma at a high level of value than it can at lower levels, and the reverse is true of purple-blue.

A Method of Visualizing Color

In order that the three dimensions of color may be clearly visualized it is necessary to have in mind some simple, orderly arrangement of all the colors in which the three dimensions of hue, value and chroma could be separately identified. A sphere was taken to serve this purpose. The top pole is taken as white, the bottom pole black; on the axis is the graduated scale of neutral grays. The five principal hues—red, yellow, green, blue and purple are spaced evenly clockwise around the sphere, with the intermediate hues, yellow-red, green-yellow, etc., evenly spaced between. A glance at the illustrations at the head of the article and on this page will indicate the application of the principle of the color sphere. The illustration below shows by cross-section characteristic chromas in two opposite hues. For convenience, the middle value, or fifth step of chroma is placed at the surface of the sphere. It will be seen that hues of stronger chroma extend beyond the surface.

Harmonious Color Combinations

The development of beautiful color combinations that will be harmonious is made possible by such a system of color classification. There are few persons who are born with eyes so sensitive to color combinations, and such intuitive colorists are as rare as composers of music. Most of us would not attempt to improvise music, yet we frequently boldly improvise color without basic study of these orderly relations underlying color harmony. With an organized system, however, it becomes easier and simpler to read and interpret color notations used by masters of color, and thereby to gain further insight into the basic truths of order and rhythm which underlie interesting and attractive harmonies of color when applied to a mechanical product. In the next article of this series the factors that affect the choice of any given color for a product will be discussed. It will be shown just how color has been applied successfully to machines and mechanical products of various kinds.



PROJECTED cross-sectional strips from the Color Sphere showing gradation from black to white along the vertical axis, and the strengthening of chroma outward from this axis. Unfortunately, the limitations of the four-color process of printing do not give entirely satisfactory reproductions of the three dimensions of color. The illustrations can only be considered, therefore, as indicators of principles

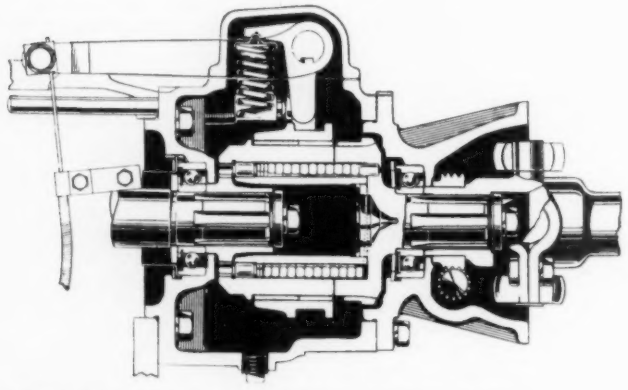
Conveniences Complicate Cars for 1932

By HERBERT CHASE

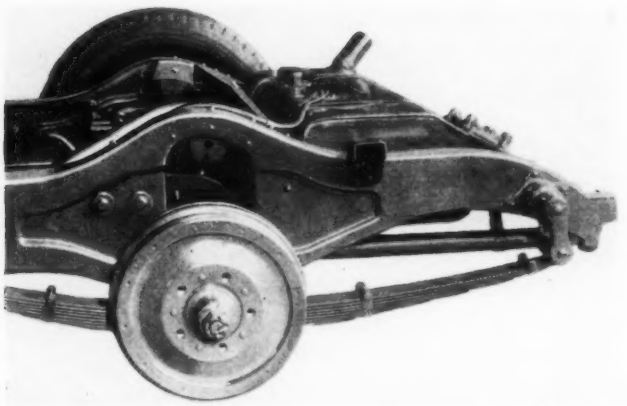
Chassis are stiffer, heavier and more complex, but control is easier. Finer lines, colorful finishes enhance appearance

CHANGES intended to make cars more convenient and less tiring to operate constitute the outstanding developments brought to light at the 1932 New York Automobile Show. Trends toward increased power and greater flexibility continue. In some cases there have been slight increases in the power-weight ratios, but in general these have been effected through increase in power rather than through decrease in weight. In fact, the general efforts to build more rigid structures have resulted in material weight increases. Instances of increased use of lighter materials of construction are comparatively rare.

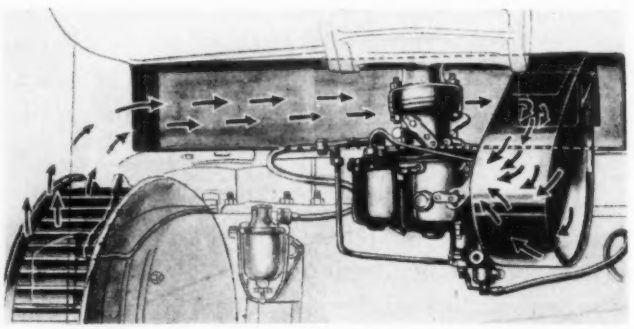
Paradoxical as it may seem, in the light of the foregoing, there is a marked trend toward the use of more rubber to add an element of flexibility. In fact, the use of rubber, especially at points where the powerplant is attached to the frame, has necessitated the addition of new stiffening elements. Having sacrificed the stiffness which a more nearly rigid mounting of a stiff crankcase provided, other means of stiffening the frame had to be developed to avoid undue flexing of the comparatively stiff bodies now almost universal.



CHEVROLET free-wheeling device employs double helical springs acting on co-axial drums



GRAHAM CHASSIS, rear end, showing the "banjo" frame construction to reinforce the rear kick-ups



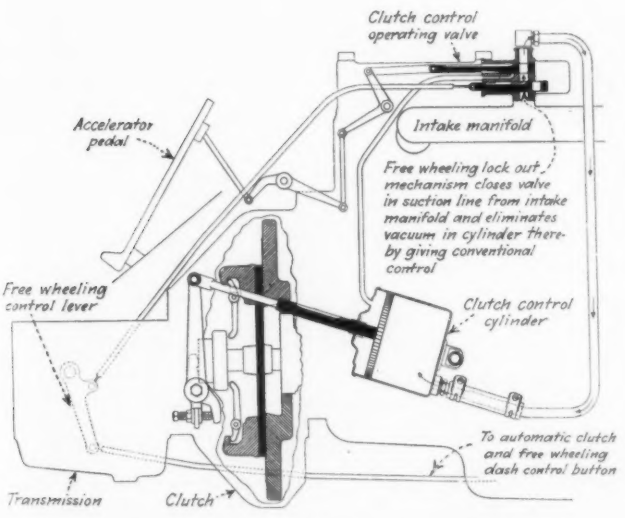
FRANKLIN shunts air from the blower provided for cooling through the carburetor to produce supercharging

Steps such as the use of vacuum-operated clutches, brakes, spark controls and chokes have added considerable complexity, as is usually the case when automatic or semi-automatic devices are added to any machine, but the greater ease of control which these devices afford is regarded as worth the extra complication. Somewhat the same may be said also of such components as the highly popular synchro-mesh gearsets, free-wheeling devices, automatic starters and various thermostatic controls.

Perhaps the outstanding mechanical development is the vacuum-operated clutch now supplied as standard equipment on several cars, especially

those in the General Motors and Chrysler lines. As applied to Buick and Cadillac-LaSalle chassis, the vacuum-operated clutch acts also as a free-wheeling device, disconnecting the engine from the gearset and permitting the car to coast without the engine acting as a brake when the clutch is disengaged. This, of course, keeps the gears of the transmission turning while coasting proceeds. In Chrysler and Dodge applications there is, in addition to the vacuum clutch, a roller clutch free-wheeling device placed back of the gearset, and this is interconnected with the clutch control in such a way that the gearset is disconnected both from the engine and from the propeller shaft when the car is free-wheeling. In consequence, only the slight inertia of the gears has to be overcome in shifting and no synchronizing device is considered necessary.

Some cars, such as Hudson, Studebaker and others, not fitted with vacuum clutches, employ a free-wheeling device and a synchro-mesh arrangement to facilitate gear shifting. This practice is followed by several makers besides those in the General Motors group to which the synchro-mesh principle was, with one or two exceptions, confined a year ago. The use of constant-mesh helical gears with jaw clutches for shifting is now almost universal except on certain cars in the lowest price range.


Clutch control operating valve
Accelerator pedal
Intake manifold
Free wheeling lock out mechanism closes valve in suction line from intake manifold and eliminates vacuum in cylinder thereby giving conventional control
Free wheeling control lever
Clutch control cylinder
To automatic clutch and free wheeling dash control button
Transmission
Clutch

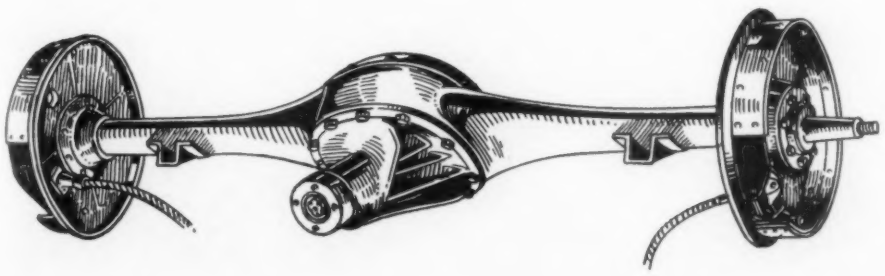
CHRYSLER cars are fitted with a vacuum-operated clutch in addition to a separate free-wheeling device. The arrangement of piston, cylinder, valves and other connecting parts is here illustrated

Auburn and Chevrolet employ the unwinding and contracting helical spring principle in their free-wheeling units. Other free-wheeling devices, except those dependent entirely upon vacuum clutches, are of the roller clutch type, but have been removed from the gearset proper, where they were incorporated last year, to a separate compartment back of the gearset. There a less viscous lubricant can be applied. A few cars have dial indicators to show when free-wheeling is in or out of use.

Power output in many engines has been boosted by the use of higher compressions and less restricted inlet passages, but in other cases has required more cylinders or increased displacement. Franklin has shunted a part of the air delivered by its cooling fan through the carbureter and thus effects a degree of supercharging which is said to yield a seven per cent power increase.

Engine refinements not already referred to include the increased use of oil coolers, inlet silencers flame-arresters and down-draft carburetors. Some makers are using nitrided piston pins and some have molybdenum-iron pistons which are tin plated to facilitate rapid seating in the cylinder bores. Nickel-chromium iron is now widely used for cylinder castings and some makes have increased the nickel content to increase hardness and wear-resistance. Aluminum alloy pistons are popular, especially those having high silicon content, as this element decreases the coefficient of heat expansion, so that clearances can be decreased, and is extremely hard and wear resistant. Bearings with steel backs and centrifugally-cast babbitt liners as thin as 0.01 in. are now being used and are said to have longer life than those with thicker liners.

Many clutches have springs or other cushioning devices between plates and hubs. Chevrolet employs a porous oil-filled graphite composition throwout bearing with an integral oil reservoir, but most throwout bearings are ball types. Hudson-Essex continue as the only cork-insert clutch users. The drive plate is of aluminum and runs in oil with better provisions for sealing.



ANGLE-TYPE rear axle as used by Hupp to increase clearance and permit lowering of body floor

Hupmobile has universal joints with needle bearings.

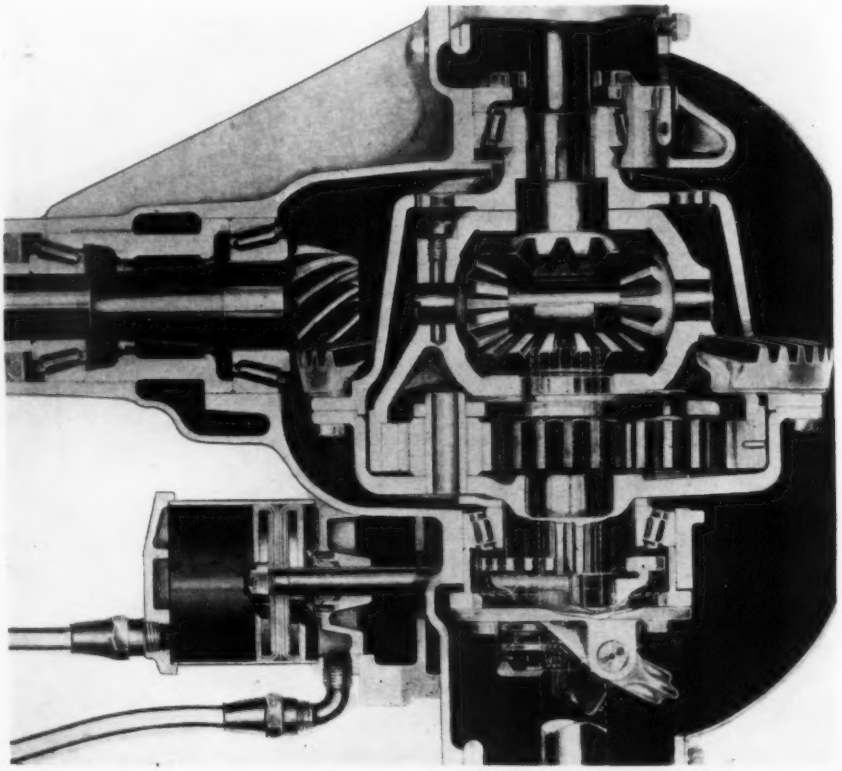
Frames have again been stiffened, many of them by the use of X-type braces. Others have increased depth of side channels and still others have box-section rails made by using two telescoped channels. Nearly all frames are now kicked up both front and rear so as to lower the body. Graham has introduced a novelty in the form of a "banjo" section at the rear kick-up, the web of the channel being widened and slotted to receive the axle, one flange being above and one blow the axle. Several expedients to avoid weaving or transverse shake of radiator and front fenders in reference to hood and body are in evidence. Hupp employs tubular V-braces and Chevrolet a cradle brace set in rubber at the center. Some cars have rubber supports for muffler straps and some fit two mufflers of different size in tandem to damp out harmonics.

There is a noteworthy increase in V-shaped radiators, many being sloped backward at the top and some narrowed at the bottom. Some still are fitted with grills, mostly built into the shell, but in other cases there is a return to shutters with thermostatic control. Fans have been shrouded in a few instances and other expedients are employed to make them quieter. Dodge and Chrysler use an X-shaped fan with four blades spaced unevenly at 50 and 130-deg. intervals. Chromium plated shells retain their popularity.

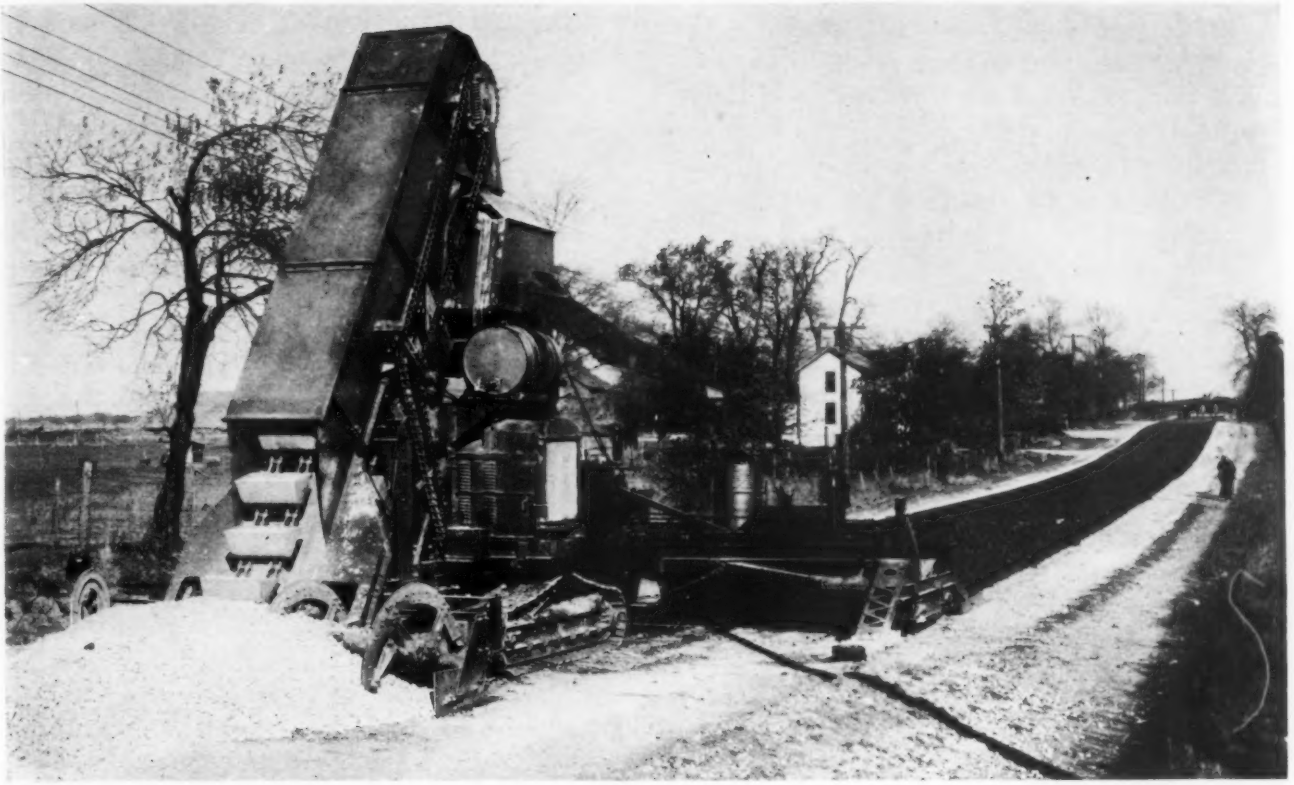
Wheels are of still smaller diameter than last year and generally are fitted with drop-base rims arranged to receive tires of somewhat larger cross section. The smaller diameter is employed to accentuate lowness and leaves the wheels only a trifle larger than brake drums. Wire wheels are standard on more cars than formerly and wood spokes are less common. Some makers offer wheels with pressed steel spokes chromium plated. Brake drums of pressed steel with centrifugally cast iron liners are quite common. Cadillac has cast molybdenum-iron drums.

Auburn presents a real novelty in its dual-ratio rear axle construction, as a part of its new twelve-cylinder chassis, which was one of the features of the show. For the high ratio this axle drives direct through the conventional spiral bevel gears, but a ratio affording a greater reduction is provided by a set of planetary gears inside the shell to which the ring gear is bolted. A shift from one ratio to the other is effected by a piston in a vacuum cylinder attached to the rear axle housing. The position of the piston is controlled by a lever on the instrument panel. Rear axles on other cars have not seen any great change except the angle types used by Hupp and Packard. In these the banjo has been tilted 45 deg. to increase clearance and permit lowering of the body.

Body developments continue the trend toward lowered tops, sloping windshields, rounded front corners, substitution of interior for exterior visors, shallower windows, adjustable seats, and flowing fender and body lines observed at the Salon and described in January *Product Engineering*. There is some tendency away from pastel shades and toward brighter colors. The vogue for black is decreasing, even the black japanning of fenders and splash aprons having been largely abandoned in favor of colored lacquers to match the body. A feature of the show was the use of metallic colors, which in the blue shades resemble blued steel, but, of course, are produced by applied finishes with pigments on the order of bronze and aluminum.



VACUUM-OPERATED dual-ratio rear axle for Auburns



A MILE of completed asphalt road is built in an 8-hr. day with this automatic machine

1932 Road Machinery

Points Progress in Mechanization

Advanced design displayed in development of hydraulic control, application of anti-friction bearings, utilization of standardized parts

MECHANIZATION of operations and the lightening of remaining hand labor constitute the outstanding trends in machinery and equipment exhibited at the annual exposition of the American Road Builders' Association in Detroit, January 11 to 15. The trends were evident in a great variety of equipment, from the Barber-Green automatic paver that completes a mile of 20-ft. bituminous road in an 8-hr. day, down to the aluminum hand shovel made to reduce the weight that the day laborer has to lift. They are found in extra operations that can be handled by one machine, in application of hydraulic controls and power, and in convenience of operation.

Outstanding in machinery was the bituminous paver and finisher designed and built by the Barber-Greene Company. This paver does not require tracks, but travels along the sub-grade on crawlers under its own power. The material is picked up at the front of the paver by means of right and left hand manganese-steel spirals and thrown into the malleable-iron buckets that carry it to a hopper whence it feeds regularly past a bitumen spray into a pug mill. The finisher behind the paver takes the material from the pug mill and distributes it by means of screw conveyors across the width of the road, a tamping device exerting a pressure of 6,000 lb. per sq.in. on the down stroke. A level road is assured without the expense of building a track or forms by providing riding shoes at a distance in front and to the rear of each crawler track, and by suspending the crawler on lever arms so that any irregularity in the sub-grade is reduced one-eighth in transmitting it to the finishing part of the machine, this irregularity being also distributed over a distance of 24 ft.

Hand shoveling and raking of asphaltic and

concrete aggregates is slow, hard labor. It has been eliminated by the finishing machines made by several companies, the machines that also assure a more even road surface. These machines are essentially gasoline-engine driven frames with one or more plow-shaped steel "screeds" that spread and tamp down the aggregates.

Another operation that has been completely mechanized is that of the spreading of gravel or sand in road-maintenance work. The Hvass spreader is a steel hopper trailer having a 40-in. sheet-steel finned disk revolving under the orifice at the bottom of the hopper. The traction of the hopper wheels drives the disk through a set of bevel gears. The sand or gravel coming from the truck into the hopper is flung out over the road by centrifugal force from the disk. Another type of distributor depends upon the distribution of the material over a long revolving drum below a longitudinal orifice in the hopper.

More Anti-Friction Bearings

There has been a decided advance in the use of anti-friction bearings and high-grade standardized parts and units in practically all of the construction machinery shown this year. Two years ago only one crusher having roller bearings was noted at the Show. The 1932 designs all have heavy-duty roller bearings and are featured as practically without vibration. On the Badger crusher, piston-ring seals inclose the bearings to keep out the dust, and the movable wearing surfaces for the toggle plates have renewable bushings and have Alemite lubrication. On this company's self-propelled gravel reduction plants roller bearings are used throughout except for the large roll shaft bearings, and forced feed and Alemite lubrication is employed.

Welding has now been adopted by designers of all classes of road machinery. Frames of such machines as maintainers and finishers are welded, and welding has eliminated the large amount of riveting formerly done on snow plows and scrapers. Weight saving has also been a factor in the adoption of welding, especially in truck bodies.

Hercules offers a clever design in a convertible road roller that can be changed on the job from a roller to a crawler tractor, and can in addition be used for scarifying or scraping. The rear wheels of the roller are removable and replacable by crawler units. The crawlers are so pivoted on a single axle that they will operate on slopes differing as much as 20 deg. without tipping the tractor. This machine is roller and ball-bearing mounted, the yokes and steering segment are of cast steel, and the rolls are of semi-steel.

The power plants in practically all road machines, including tractors and rollers, are automotive jobs, taking advantage of the latest engineering advances in engines, transmissions, and clutches. Graceful lines also characterize such machines as road rollers and tractors. Hercules is using bright red and orange colors for its machines. Color, however, is usually specified by the highway commission or the contractor. Speaking of automotive experience, Chrysler is offering an industrial engine built on automotive lines for installation in compressors, tractors, concrete mixers, pavers, or shovels.

Specially Designed Trucks

Trucks for road building are now specially designed for the job. Drives for the hydraulic pumps on dump trucks are practically all taken from the transmission, but the method of application of the mechanism varies. The usual method is to have the hydraulic cylinder placed longitudinally in the rear center of the chassis with a toggle linkage or a roller and track. The White dump truck, however, has two sets of telescoping tubes acting directly on the body from a pivot near the rear axle.

On the Wood unit the crosshead on the end of the piston rod has two sets of steel rollers, one set rolling on the track of the sub-frame and the other acting against large wedge cams attached to the beams of the body. This company also has a design of telescopic lift, but operating from the forward end of the dump body. Steps are being taken by designers to reduce the weight of dump bodies in order to permit more pay load. The Heil Company has saved nearly 2,000 lb. on a 5-yd. body by using aluminum alloys.

Concrete mixing trucks have been able to save construction time in the preparation of the mix en route, and a number of designs were exhibited. The Blaw-Knox Truckmixer has an octagonal steel drum with a cone at each end. The drum is revolved by means of a separate gasoline engine mounted behind the truck cab, with an automatic reversing mechanism in the transmission.

The Riddell Company's "Octopus" maintainer has eight driving wheels in the rear, each set of four geared together for non-slipping in soft spots and ditches. The main drive shaft is made to fit the standard tractor axle so that the pneumatic drive wheels may be interchanged on the job with crawlers or with solid wheels. The new tubular-frame grader designed by this company is unique. The heavy tube on the center-line of the machine eliminates framwork and gives a clear view of the blade.

Linkages for Operating Band Clutches and Brakes

For the general run of conditions, one or another of these four designs of band clutches and four designs of band brakes will be found applicable. If necessary, of course, they can be modified for particular purposes

By A. C. RASMUSSEN
Mechanical Engineer

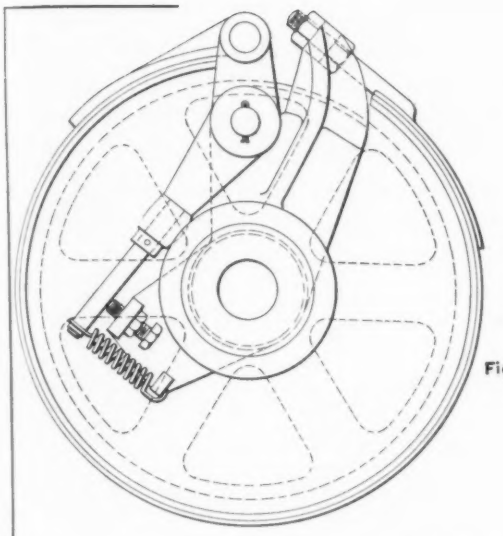


Fig. 1 - Outside Band Clutch Operated by Roller and Cone

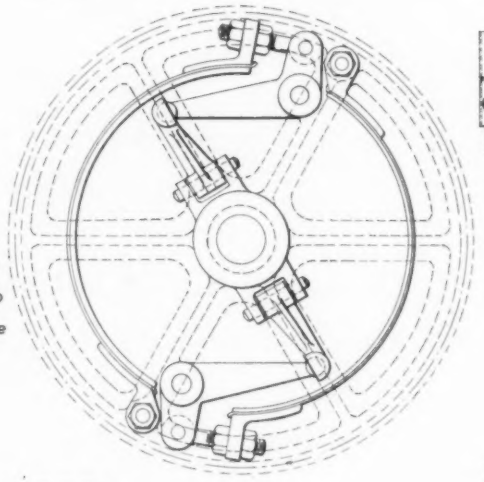


Fig. 2 - Outside Band Clutch Using Two Half Wrap Bands with Intermediate Equalizer

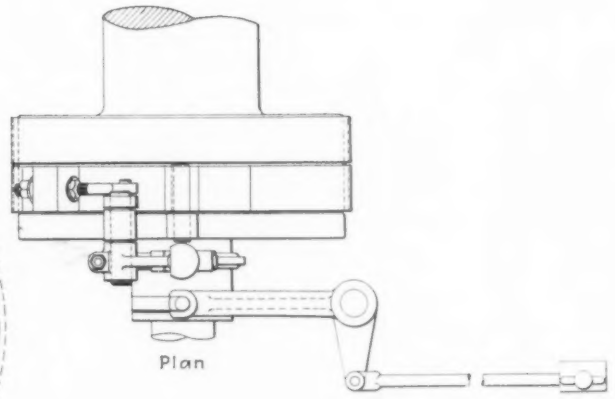
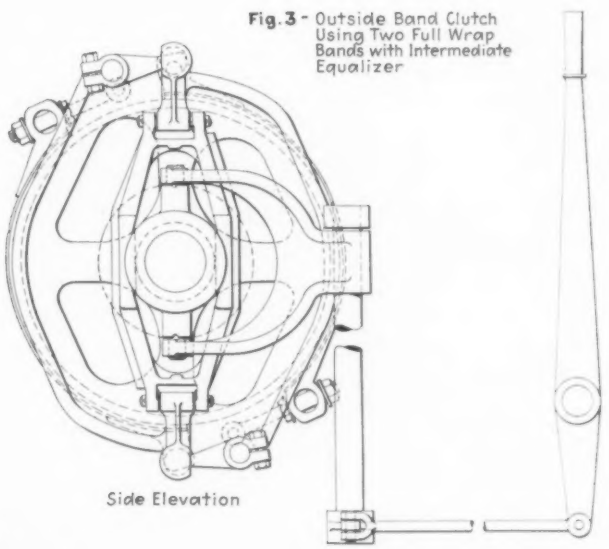


Fig. 3 - Outside Band Clutch Using Two Full Wrap Bands with Intermediate Equalizer



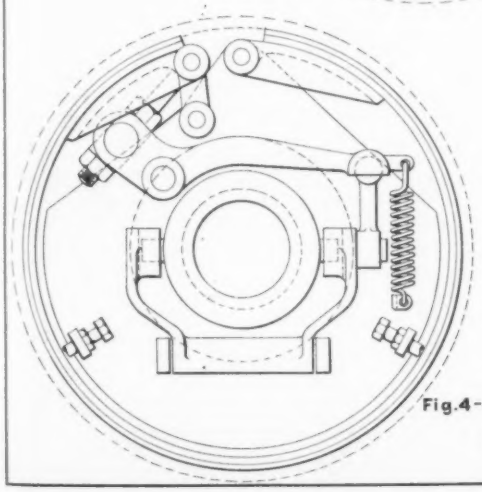


Fig. 4 - Inside Band Clutch Operated by Yoke Having Movement Along Shaft

Courtesy National Equipment Corp.

Linkages for Operating Band Clutches and Brakes (continued)

Every month we are planning to collect and feature a new selection of correct proportions for certain generally useful machine elements and standard constructions, plus various types of mechanisms available for specific purposes. These typical designs will have direct applications over wide fields; taken together with the Reference Book Sheets in each issue, they will provide the engineer with an invaluable library of short cuts and time savers

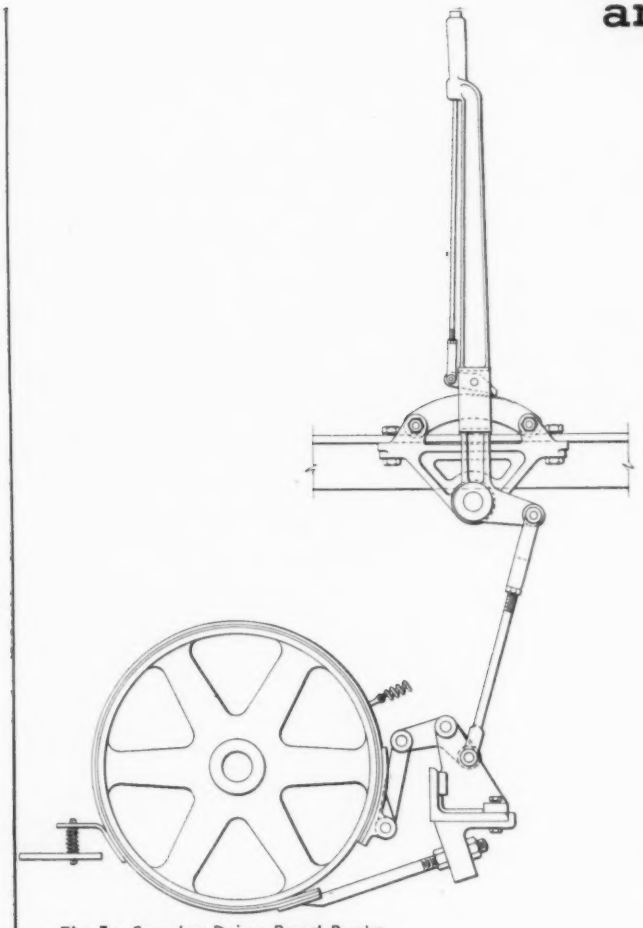


Fig. 5 - Crawler Drive Band Brake Operated by Ratchet Lever

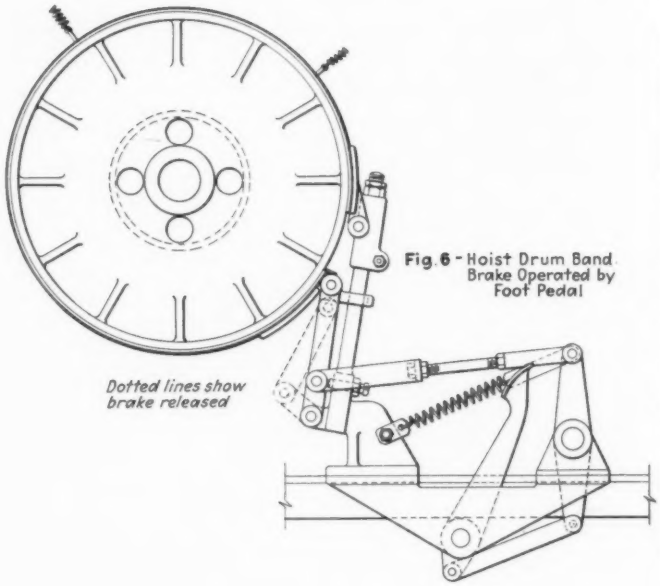


Fig. 6 - Hoist Drum Band Brake Operated by Foot Pedal

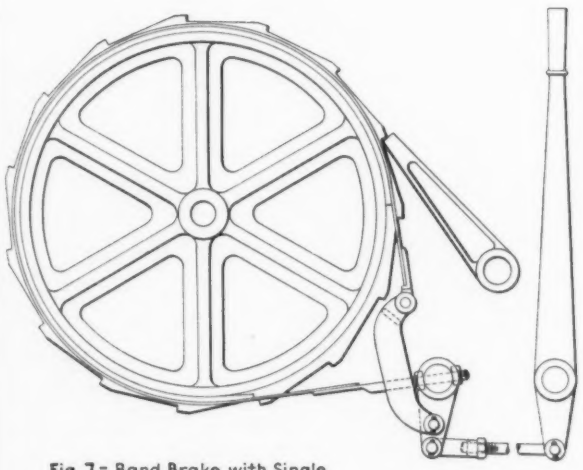


Fig. 7 - Band Brake with Single Toggle Action

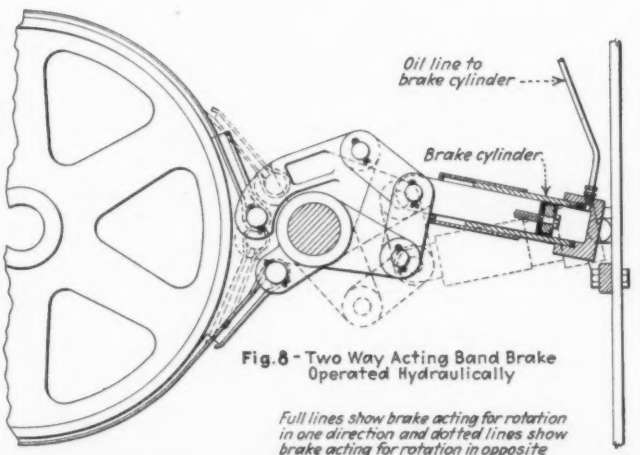


Fig. 8 - Two Way Acting Band Brake Operated Hydraulically

Full lines show brake acting for rotation in one direction and dotted lines show brake acting for rotation in opposite direction

Courtesy Insley Mfg Co.

Spur Gear Tooth Strength Chart

REFERENCE BOOK SHEET

IN THE DESIGN of gears, proper attention must be given to contact stresses, number of teeth in contact, hardness, wear, lubrication and similar factors. However, it is necessary to make the gear strong enough before these other factors are taken into consideration. This chart was constructed in order to facilitate calculations of gear tooth strength. The accuracy of the chart is well within that with which the load and strength of the material are known, hence results obtained can be used for all ordinary purposes. Where greater accuracy is required, these charts furnish a quick method for getting a first approximation which will be of material aid to obtaining the final results.

The Lewis formula for the strength of gear teeth can be written in the following form:

$$HP. = S_o \frac{\left(\frac{a}{a+V}\right) f \pi y V}{33{,}000\, p}$$

$HP.$ = horsepower transmitted
V = pitch velocity in ft. per min.
y = form factor of tooth
p = diametral pitch
a = factor for determining the working stress
S_o = allowable stress at O pitch velocity
f = face width of gear tooth
n = number of teeth
N = rev. per min.

$$V = \frac{\pi n}{12\, p} N$$

When this is substituted in the above equation we have:

$$HP. = S_o \left(\frac{a}{a + \frac{\pi n N}{12 p}} \right) \frac{f \pi y \frac{\pi n N}{12 p}}{33{,}000\, p}$$

Apparently there are eight variables in this equation. However, S_o is fixed by the material used, a must be determined from experience or experiment, y is a function of the number of teeth, and f must be determined arbitrarily. This last is usually taken as between $\frac{3\pi}{p}$ and $\frac{4\pi}{p}$. This leaves four variables to be considered.

It will be noted that if p and n are fixed, there will then exist a relation between HP and N. Therefore, for any particular value of n a chart can be drawn for various values of p, as is shown above. Likewise, a chart for any particular value of p with n as the variable could be constructed. By superimposing several charts of these two types, a general one, as shown on the following page, is obtained.

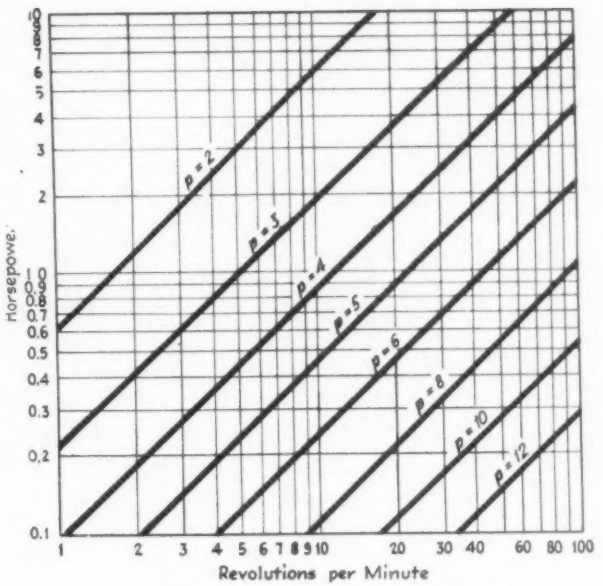


Chart for determining strength of teeth of a 15-tooth gear. By superposition, as shown on the next page, a comprehensive chart is obtained

Example—Assume that it is desired to find the size of a steel pinion to transmit 10 hp. at 100 r.p.m. The chart shows that a 5-pitch, 30-tooth steel gear with 2-in. face width will meet the requirements. If a smaller number of teeth is desired, a 4-pitch, 20-tooth, or a 3-pitch, 12-tooth gear will be of the correct strength.

If the gear is to be made of cast iron, Micarta, or Bakelite, which materials have values of $S_o = 8{,}000$ lb. per sq.in., the same chart can be used but the gear must be designed to transmit 25 hp., this being equivalent to reducing the working stress in the ratio of 2.5 to 1. According to the chart, a 3-pitch gear having between 25 and 20 teeth can be used. By interpolation a 22-tooth pinion will be strong enough.

Spur Gear Tooth Strength Chart

REFERENCE BOOK SHEET

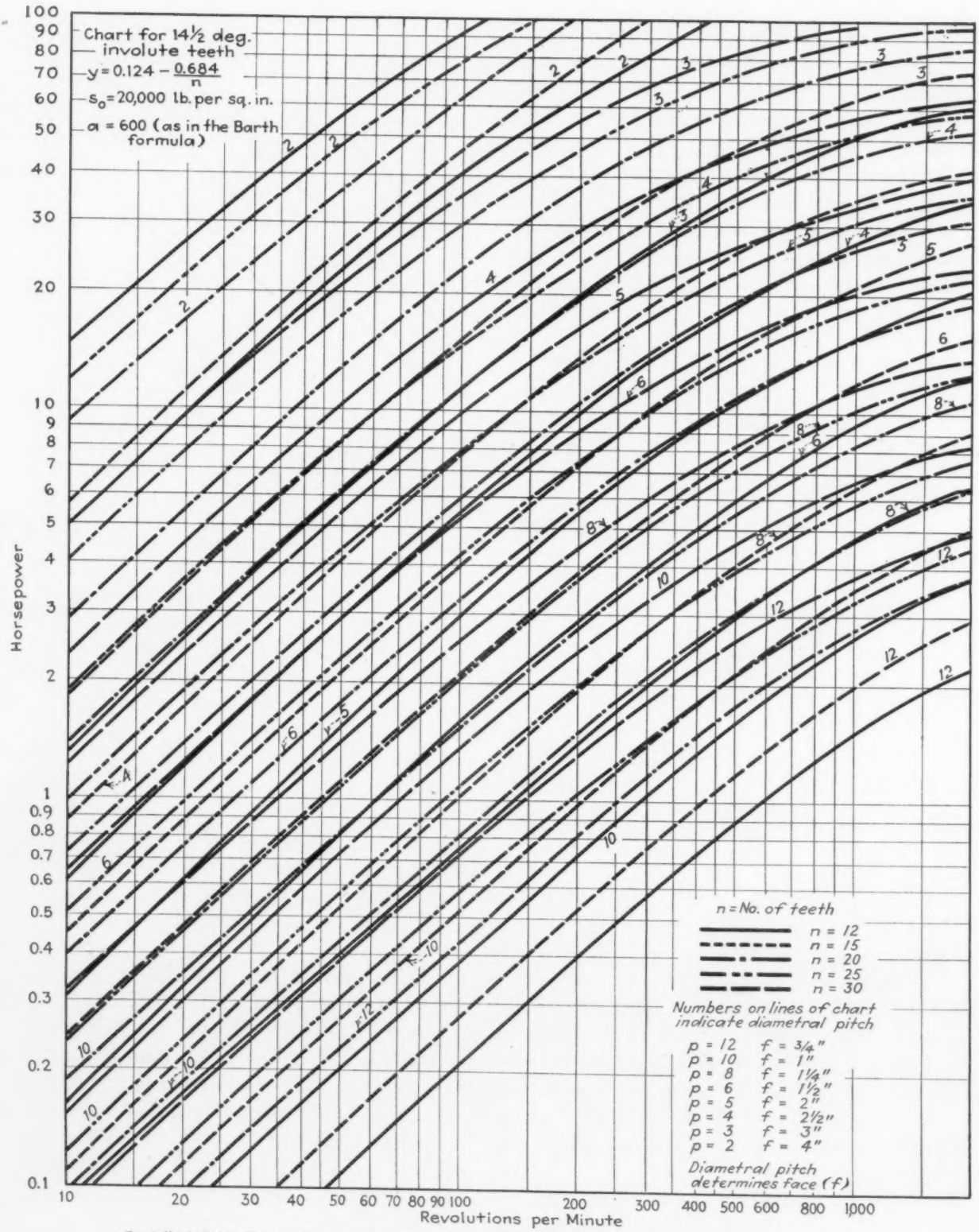


Chart for 14½ deg. involute teeth
y = 0.124 − 0.684/n
s_o = 20,000 lb. per sq. in.
a = 600 (as in the Barth formula)
Horsepower
Revolutions per Minute
n = No. of teeth
n = 12
n = 15
n = 20
n = 25
n = 30
Numbers on lines of chart indicate diametral pitch
p = 12 f = 3/4"
p = 10 f = 1"
p = 8 f = 1¼"
p = 6 f = 1½"
p = 5 f = 2"
p = 4 f = 2½"
p = 3 f = 3"
p = 2 f = 4"
Diametral pitch determines face (f)

Contributed by Emory Kemler, Instructor in Mechanical Engineering, University of Pittsburgh and L. L. Thomas, Enginering Division, Gulf Research Laboratories

© Product Engineering

Welding—the Engineer Can Make It or Break It

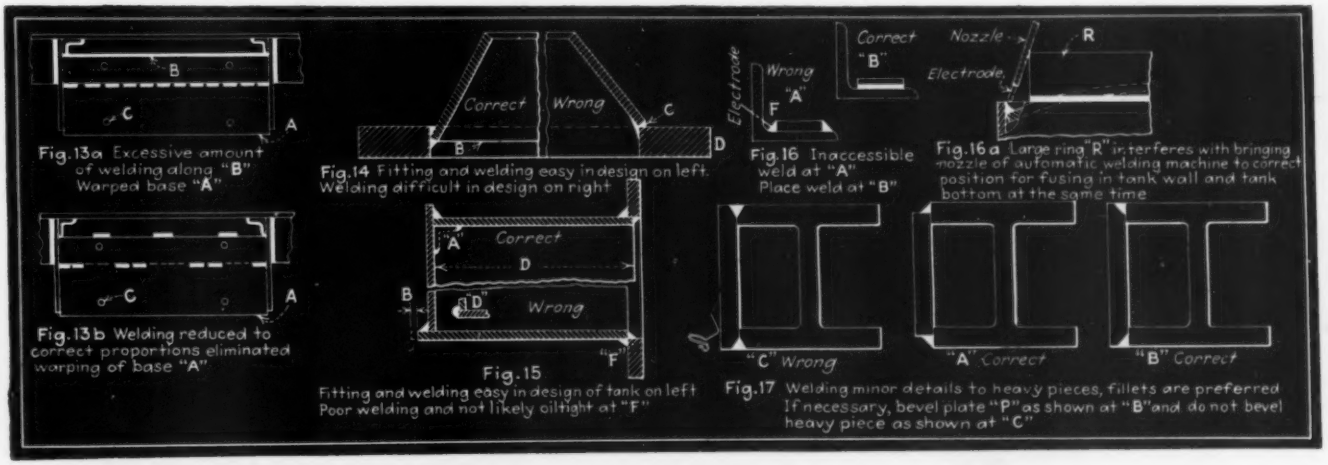
By R. KRAUS
Supervisor of Welding Inspection, Westinghouse Electric & Manufacturing Company

Conclusion of the article begun in the January number. Eliminating excessive welding and handling, using fillet welds, increasing accessibility, designing to speed assembly—all these make for increased economy

SURPLUS weld metal not only means greater cost of the apparatus; it can, in addition, be detrimental if it causes warping in lighter structures, due to the excessive amount of heat applied to the material. Fig. 13-A shows a support for an operating mechanism which will be bolted to plate *A*. Too much welding was called for; the plate *A* warped to such an extent that the structure had to be scrapped. Actually not much more welding is required than corresponds to the strength of the holding-down bolts. The second design, Fig. 13-B, with welding reduced considerably, proved very satisfactory. The plate *A*, which had to be machined in advance, was warped less than $\frac{1}{32}$ in. in any direction after welding.

Besides reducing weld metal to a minimum, the design can also help to facilitate assembly and produce a structure that can be finished in a workmanlike manner. Fig. 14 shows a part of the vertical bearing support; a joint is to be made between a plate and a conical shape. If line *B* is set inside of the opening in the plate, fitting will be easy and both welds can be made downward in position. Some unavoidable variation in level of the edge *B* will be of no consequence. In the design on the right, welding will be difficult, as neither one of the welds is readily accessible; besides the edge *C* will not be touching plate *D* all around the periphery, but an appreciable gap in spots will be found as shown. It is unlikely that in the latter design either one of the welds will be oil-tight.

The problem of joining component parts suitably appears in many variations. It might be helpful to show another example. A diagram of a tank is shown in Fig. 15. In the right-hand part, edge *F* would have to be fitted closely in the design on the bottom, but with no extra work required on the design at the top. The joints at the left are also of some interest. At the top there is no difficulty in maintaining the depth *D*, and the fillet can be made easily to correct size; it is also accessible for tests if it is oil-tight. In the design at the bottom, sufficient allowance *B* should be made for variation in manufacturing; otherwise, a weld similar to detail *D* will not be infrequent. The test of a tank with a weld on the under side is difficult and, therefore, not economical, if it can be


B
C
A
Fig. 13a Excessive amount of welding along "B" Warped base "A"
C
A
Fig. 13b Welding reduced to correct proportions eliminated warping of base "A"
Correct
Wrong
C
D
B
Fig. 14 Fitting and welding easy in design on left. Welding difficult in design on right
"A"
Correct
D
B
D
Wrong
"F"
Fig. 15
Fitting and welding easy in design of tank on left Poor welding and not likely oiltight at "F"
Electrode
Wrong
"A"
F
Correct
"B"
Fig. 16 Inaccessible weld at "A" Place weld at "B"
Nozzle
R
Electrode
Fig. 16a Large ring "R" interferes with bringing nozzle of automatic welding machine to correct position for fusing in tank wall and tank bottom at the same time
"C" Wrong
"A" Correct
"B" Correct
Fig. 17 Welding minor details to heavy pieces, fillets are preferred If necessary, bevel plate "P" as shown at "B" and do not bevel heavy piece as shown at "C"

avoided. For large tanks, with a shell built from several sections, an angle *A* can be used to advantage to facilitate assembly; but the welds along it should be intermittent, otherwise oil leaks will probably appear. It can take days and even weeks before oil seeping through one defect in the inside weld will find its way through a defect in the outside weld and appear as a leak. By that time the apparatus has left the test floor.

Accessible welds, only, should be asked for, which is not the case in *A*, Fig. 16. To make fillet *F* satisfactory, the electrode would have to be held as shown in dot and dash, which is not possible. Fusion of welds made with bent electrodes is doubtful and observation in process by either welder or inspector is impossible. The fillet should be placed as shown at *B* in the same figure. In most cases welds in that location can satisfactorily take care of the stresses. With automatic welding the problem of accessibility appears in another form. Some part of the machine or detail of the structure to be welded prevents the nozzle from being brought to the correct position for fusion in both component parts. This is illustrated in Fig. 16-A, where the ring *R* interferes with the nozzle being adjusted to the right angle for welding. In the illustration it may be only necessary to change the order of welding on item *R*. In this connection the designer should be acquainted with practical welding and indicate by note "Weld item *X* on after item *Y* is welded to item *Z*" or in some similar way "flag" the drawing, unless the set-up is such that work is routed to avoid such difficulties. It is always in order, however, for the engineer to know the entire procedure in the weld shop and where necessary change design to keep accessibility a maximum. To do this is good welding design.

In the transition from casting to welding practice, the elements of the two processes must be understood and design made accordingly. It should be noted also that the welding together of component parts made by both processes often eliminates difficulties, that is, a properly designed steel casting can often be welded into a plate or structural steel assembly with a considerable overall economy. This is especially true if the cast steel part can be a more or less standardized stock part applicable to a number of different sizes or types of apparatus.

Fillet welds are preferable to vee welds. In Fig. 17, a plate is joined to a heavy H-beam by means of fillet welds. If there is a design objection to the fillets, the plate can be beveled, but beveling of the plate and the H-beam, or the H-beam alone, should be avoided if possible. Crane handling would be necessary to turn the beam over; most burners prefer to guide the torch horizontally instead of vertically as they make a better job of it in a horizontal position.

Design in sheet metal work presents similar opportunities for the saving of material and using the minimum amount of welding. Fig. 18-A and B show the correct and the wrong way of making a shallow box. The size of the material and the amount of welding is given with the drawings. In the latter case, there is about 50 per cent more material and almost twice the welding necessary. These are appreciable in quantity production.

The design is frequently responsible for the fact that work has to be handled unnecessarily during welding. A small section of a frame for mounting of a large number of control accessories is shown in Fig. 19-A; it is built up of a channel and angles. The welds have been placed on front and rear, requiring turning over of the work. Fig. 19-B shows the weld located on one side only. The parts can all be clamped in the jig and the welds finished without further handling. A supporting bracket, Fig. 20, also manufactured in quantities, presented a similar problem. Locating the welds on one side made the work easier.

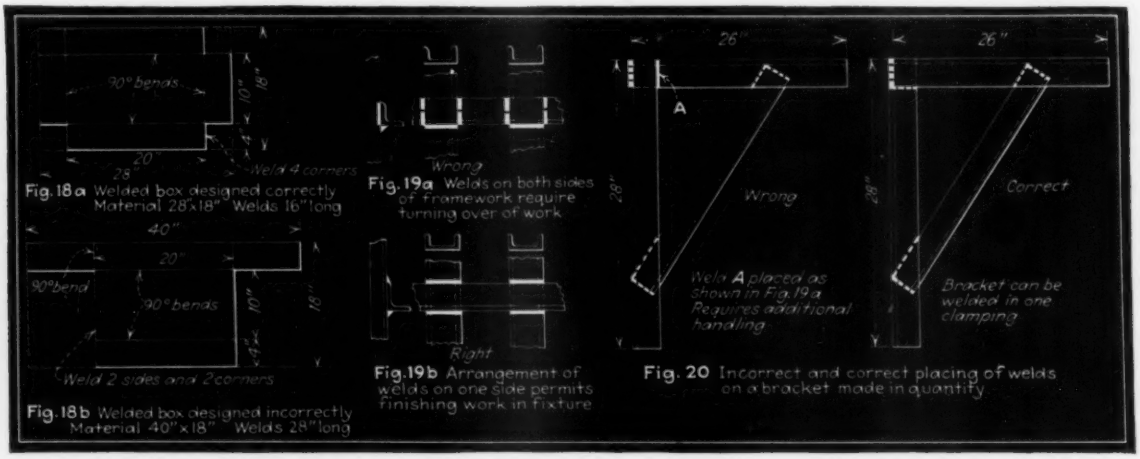


Fig. 18a Welded box designed correctly Material 28"x18" Welds 16" long

Fig. 18b Welded box designed incorrectly Material 40"x18" Welds 28" long

Fig. 19a Welds on both sides of framework require turning over of work

Fig. 19b Arrangement of welds on one side permits finishing work in fixture

Fig. 20 Incorrect and correct placing of welds on a bracket made in quantity

Torsional Vibration — How to Prevent It

Rotating shafts that transmit or are subjected to periodic forces, as in milling machine and woodworking cutter-head spindles, might have excessive torsional vibration if not calculated to avoid resonance. Yet the necessary calculations, explained in this article, are so simple that engineers cannot afford to omit them and "take a chance"

By DAVID B. TURCOTT
Mechanical Engineer

ENGINEERING calculations are not always merely a matter of determining the strength and static deflection of parts, but often involve the consideration of the inertia forces and deformations due to the periodic application of forces and their relation to the natural vibration of the system. All revolving masses, such as shafts carrying loads and transmitting power, constitute an elastic system having a natural frequency of vibration in a transverse as well as in an angular direction. Vibration in a transverse direction is produced by the displacement of the center of gravity of the revolving masses from the geometric axis of rotation, while the vibration in an angular direction, that is, torsional vibration, is caused by the inertia of the revolving masses.

Let us consider a flywheel, or any other rotating mass, mounted on a shaft being turned about the axis against the torsional resistance of the shaft, while one end of the shaft is held fast, as shown in Fig. 1. If now the flywheel is suddenly released it will oscillate in an angular direction until friction dissipates the energy. The shaft in this case may be considered as a spring rod under torsion. The number of oscillations the flywheel will make in a given unit of time depends on its moment of inertia, and on the diameter and length of the shaft. This number of oscillations in a given unit of time is known as the "natural frequency" of vibrations, because it depends on the properties of the revolving masses and the shaft, rather than application of external forces. When deflections

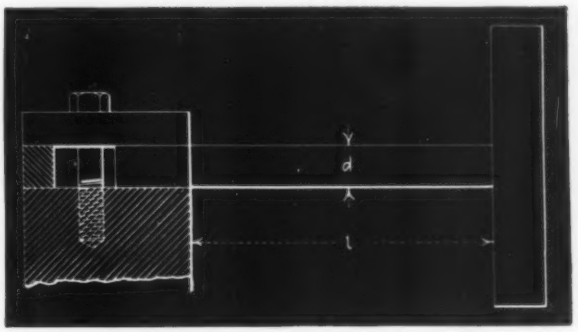


Fig. 1—With one end gripped, and the wheel given an initial rotational impulse, the mass will have angular oscillations at its natural frequency

are imparted to the shaft by the periodic application of external impulses, it is called "forced" vibration.

When the number of forced vibrations imparted to the system corresponds to the number of natural vibrations a condition of resonance occurs at which the amplitude of vibration is violent and may reach dangerous magnitudes. The vibration at resonance is limited only by the damping forces due to friction. The frequency of natural vibration, however, is not influenced to any great extent by the damping forces, and, therefore, the speed at which resonance occurs is practically independent of friction. The speed at which the condition of resonance is encountered is known as the "critical speed." Fig. 2 illustrates the relation between the amplitude of vibration and the number of external impulses per minute, from which it will be noted that the maximum vibration occurs at the critical speed and is consider-

ably less either below or above the critical speed. The critical speed relative to bending deflection produced by the displacement of the center of gravity must be distinguished from the critical speed for torsional vibration. Torsional vibrations are quite often encountered in reciprocating engine crankshafts and depend on the relation of the periodic application of forces through the connecting rod to the natural frequency of oscillation of the entire mass carried on the crankshaft.

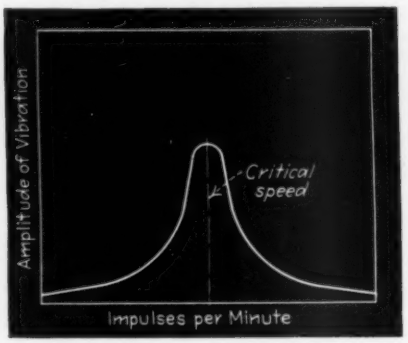


Fig. 2 — When the rate of periodic impulses is equal to the natural frequency, the amplitude of vibration is a maximum, and the corresponding r.p.m. of the shaft is called the critical speed

Torsonal vibrations in crankshafts have been the subject of considerable study in the last few years. Torsional vibrations, however, are not confined to crankshafts and are sometimes encountered in revolving shafts of circular cross-section when subject to torsional impulses in such systems as exemplified by multi-knife cutterheads, of woodworking machines, jaw and hammer crushers, or other revolving systems subject to a definite number of impacts per revolution. A four knife woodworking cutterhead, for instance rotating at 3,600 r.p.m. imparts to the shaft 14,400 torsional impulses each minute. If, now, the number of natural vibrations of the revolving masses happens to be close to 14,400 per min., or a whole multiple thereof, a condition of resonance is possible. Violent vibrations of torsional resonance become evident only in actual operation when torque is transmitted, and they cannot be detected when the masses revolve "idle." This is the reason that torsional vibrations cannot be detected by "feel" or noise while the parts run without load. Furthermore, the most perfect balancing cannot have any effect on this condition.

In woodworking cutterheads torsional vibration affects the smoothness of planing, creating a condition which usually mystifies the operator. The only remedy, of course, is a complete redesign of the spindle with due regard to torsional impulses. In the following it will be shown how to check up the torsional properties of the shaft to avoid torsional vibration. By calculating the number of natural vibrations per minute it is possible to find out whether a condition of resonance exists. When dealing with shafts of circular cross-section the problem is much simpler than in the case of crankshafts. The labor involved in such calculations is not great, and a modern designer can not afford to ignore them.

If the shaft diameter varies in different parts it may be reduced to one shaft having a constant diameter, thus simplifying calculations. The resulting equivalent shaft will be of such diameter and length that the torsional properties will be unchanged from those of the original shaft. Since the angle of twist varies inversely as the fourth power of the diameter and directly as the length of the shaft, the following formula may be used:

$$l_e = l\left(\frac{d_e}{d}\right)^4 \qquad (1)$$

where l_e = length of the shaft section reduced to diameter d_e in inches
l = length of section of original diameter d in inches
d_e = standard diameter to which the shaft is reduced in inches
d = original diameter of length l in inches.

The lengths of the sections reduced to a standard diameter are then simply added together.

If more than one rotor is mounted on the shaft it is necessary to find the equivalent weights, assuming all inertia forces acting at the same radius of gyration. The following formula may be used:

$$W_e = W\left(\frac{r}{r_e}\right)^2 \qquad (2)$$

where W_e = equivalent weight in lbs. acting at radius r_e
W = original weight acting at radius r
r_e = radius of gyration to which all masses are reduced
r = radius of gyration of original weight W

With the above simplifications, the natural frequency of torsional vibration can be easily computed. In the following simplified formulas for steel shafts, the acceleration of gravity was assumed to be 32.6 ft. per sec. per sec. The formulas for one and two masses are given. Expression for more than two masses is quite complicated and will not be given here. In practice, outside of engine crankshafts, two masses are encountered more often than any other combination. The frequency of complete (to and fro) vibrations for one rotor mounted on a shaft is:

$$f = \frac{204{,}000\ d^2}{r\sqrt{l\,W}} \qquad (3)$$

For two rotors mounted on a shaft, the frequency of vibration is:

$$f=\frac{204{,}000\,d^2\sqrt{W_1+W_2}}{r\sqrt{l\,W_1\,W_2}} \qquad (4)$$

where

W_1 and W_2 = the weights of two masses on the same shaft reduced to a common radius of gyration.

For an illustration of the use of the above formulas, consider a shaft carrying two masses, as shown in Fig. 3. No bearings are shown because their location has little influence on the frequency of torsional vibration. The operating speed of the system illustrated in Fig. 3 is 6,000 r.p.m., W_1 is a three-knife steel cutterhead weighing 48 lb., and is of such shape that it may be considered as a solid cylinder as far as inertia forces are concerned. The symbol W_2 represents the rotor of an induction motor, and weighs 16.3 lb. including the portion of the shaft inside the rotor. When the revolving masses are shrunk or keyed on the shaft, precluding the possibility of movement between them, the free length of the shaft may be measured from the end of the rotor. In this example, the mounting of the rotor W_2 will be considered rigid, and the shaft will be measured from one end, while the mounting of the cutterhead W_1 will be such as to allow some play. The length of the shaft will be measured from the center of W_1 to allow for the twisting of the shaft inside the bore. Three sections of the shaft of different diameters must be considered:

(*a*) — 1.5 in. dia. — 3 in. long
(*b*) — 2.0 in. dia. — 4 in. long
(*c*) — 1.75 in. dia. — 5 in. long

Sections *a* and *c* can be reduced to a uniform diameter of 2 in., that is to the same diameter as the section *b*. Using Equation (1) we get:

For section (*a*) $l_e=3\left(\frac{2}{1.5}\right)^4=9.48$ in.

For section (*c*) $l_e=5\left(\frac{2}{1.75}\right)^4=8.53$ in.

The three sections now have a uniform equivalent diameter of 2 in. and their equivalent lengths can be added, hence:

$$l=9.48+4+8.53=22.01 \text{ in.}$$

Reducing the weight of W_2 to the same radius as W_1, that is, 2.12 in., by using Formula (2):

$$W_e=16.3\left(\frac{1.24}{2.12}\right)^2=5.56 \text{ lb.}$$

The simplified system equivalent of one in Fig. 3 is shown in Fig. 4. Now the frequency of torsional vibration may be calculated by substitution in Formula (4). Influence of the mass of the free shaft is small and was neglected.

$$f=\frac{204{,}000\times 2^2\times\sqrt{48+5.56}}{2.12\sqrt{22.01\times 48\times 5.56}}=36{,}760 \text{ vibrations per min.}$$

With three knives in the cutterhead revolving at 6,000 r.p.m. the impulses per minute equals:

$$3\times 6000=18{,}000 \text{ per minute.}$$

In this example the frequency of natural vibrations, being 36,760 per min., is almost exactly two times the forced vibration. Thus a critical speed is likely, particularly if we consider that the calculations of natural frequency are only approximately correct because certain assumptions regarding rigidity of the parts of the shaft have been made while actually the condition will be somewhat different. It is therefore evident that the spindle in this example might be subject to torsional vibrations in operation. This condition can be avoided by increasing the diameter of the shaft, and, since the resistance to torsion varies as the fourth power of the diameter, a small increase of the diameter will result in a big change in the number of natural vibrations per minute and thus correspondingly change the critical speed.

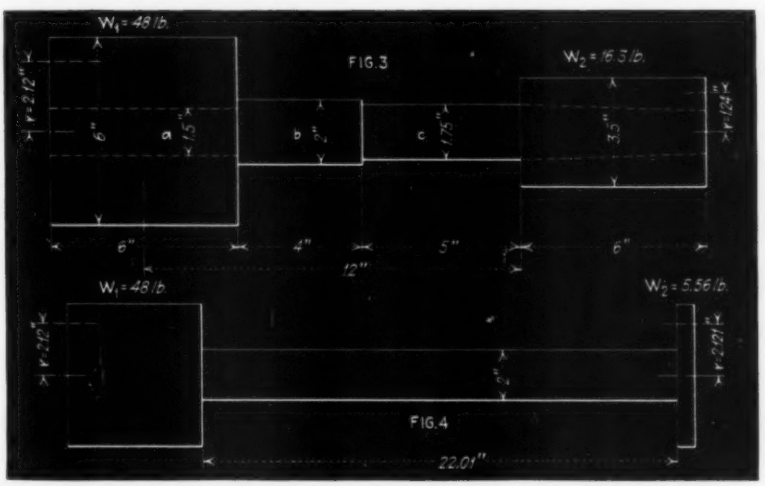


Fig. 3—Two masses mounted on a shaft having different diameters is the most usual combination. The solution of this problem is given in the text

Fig. 4—The mass W_2 on the shaft shown in Fig. 3 has been reduced to an equivalent mass at the same radius of gyration as W_1. The variable diameter shaft has been reduced to an equivalent shaft of constant diameter

COMMENT and SUGGESTION

Three Corrosion-Resistant Materials in One Small Filler Cap

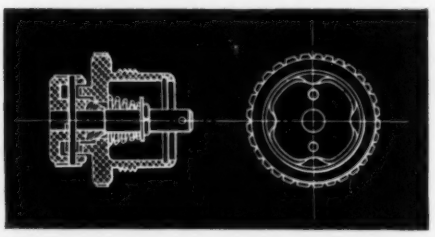
By Seth G. Malby
President, Aluminum Screw Machine Products Company

AN ingenious part that is designed for high production almost entirely on the screw machine is the filler cap on the gasoline tank of an outboard motor shown in the illustration. Since the gasoline tank on an outboard motor is an integral part of the motor, the filler cap on the tank must be so constructed that it will prevent gasoline leakage when the motor is removed from the boat. At the same time, it must permit air to enter the tank while the motor is running. It must also be resistant to the corrosive action of sea water.

The valve stem is made of strong aluminum alloy rod, turned and drilled to receive the valve, valve head, spring clip and ring. The valve is machined from stainless steel and pressed onto the valve stem. The aluminum alloy head is knurled for finger grip, drilled to fit the upper end of the valve stem and trepanned inside. A stainless steel pin inserted through a cross hole drilled in the head and valve stem holds the head to the stem and keeps the head in either the "open" or "closed" position by dropping into the proper slot in the body.

The body is an aluminum alloy die casting, machined to accommodate the valve and threaded to fit the tank. The valve stem, valve head, valve and pin assembly is inserted in the body and held in place by means of a Monel metal spring, a sheet aluminum washer, and a Monel metal spring clip.

A sheet aluminum vent disk, pierced to allow the aluminum valve stem to protrude through it, fits in the filler cap body. It is held in place by bending over the edges of the die casting. Two small holes in the disk provide the necessary air passage. In order to prevent the filler cap from becoming lost while disengaged from the tank, a chain and anchor, not shown, are attached to the valve stem.



Corrosion resistant cap made of aluminum, stainless steel, and Monel metal

Analysis of Differential Gear Trains

By Francis W. Shaw
Tool and Gear Consultant

WITH reference to Mr. Michael's article, "Differential Planetary Gearing," that appeared in the November number of *Product Engineering*, there is evidently an error and a deficiency in the article in that the answer obtained for the last problem presented in that article is incorrect.

Using the author's terminology, the commonly used formula for determining the speed ratio in a planetary differential transmission is:

$$\frac{N_C}{N_O} = 1 - \frac{T_A\,T_D}{T_B\,T_C}$$

This equation can be derived easily by the summation method. Using the author's nomenclature and gear train, we have by referring to the accompanying figure, the following relationship. If the wheel D be rotated once in a counter clockwise direction while the arm OZ is held stationary, the speed ratio would then be:

$$\frac{N_C}{N_O} = \frac{T_A\,T_D}{T_B\,T_C}$$

If the whole gear unit now be given a rotation in the clockwise direction, the effect will be that arm OZ will have a clockwise rotation of one revolution, while the gear wheel D, will be stationary.

Designating clockwise rotations with a plus sign and counter clockwise rotations with a minus sign, we then have that the ratio of speed will be:

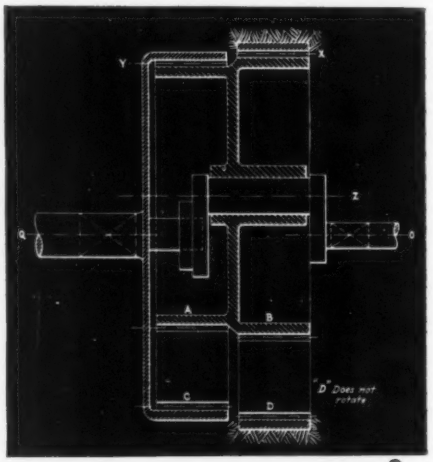
$$\frac{N_C}{N_O} = 1 - \frac{T_A\,T_D}{T_B\,T_C}$$

Substituting $T_C = 40$, $T_B = 34$, $T_A = 33$, $T_D = 40$, we have:

$$\frac{N_C}{N_O} = 1 - \frac{33}{34}$$

or,
$$\frac{N_O}{N_C} = 34$$

In deriving his Equation 1, Mr. Michael failed to take into consideration that this equation is true only when the diametral pitches of all gears are the same. It is evident that they will not all be in the same proportion when different diametral pitches are used. It can also be demonstrated that if the pairs of gears are of like pitch, the above equation can be made the same as Mr. Michael's Equation 1.



Planetary differential gear train, wheel *D* being the fixed member

The method for determining the number of teeth, as presented in the above-mentioned article, has some advantages, yet simpler methods are available. The expert designer, from

past experience, has always some conception of the over-all dimensions of the object of the design. It is unlikely that he would start with the tooth difference only in mind, as suggested by Mr. Michael. More likely, he would provisionally decide upon the over-all dimensions of either the gear D or the gear C. Then he would decide upon the throw of the eccentric shaft, having some regard for the tooth difference between P and Q, and R and S, for this difference cannot be too small in ordinary circumstances. The diameter difference, be it noted, in both pairs is always equal to the throw.

Where the throw can be comparatively small, as in planetary gearing, it is possible to employ tooth differences as low as two, for teeth generated with Fellows-type stub cutters and with certain tooth corrections.

As an example, in determining the number of teeth for a definite ratio, or a good approximation thereto, let the desired speed ratio be —300. Let $T_D = 60$, $T_B = 54$ (the minimum tooth difference having been fixed at 6). It is required to determine the number of teeth in A and C, the pitch being the same as that of gears D and B.

Applying the fundamental equation for the speed ratio, we have:

$$\frac{T_A T_D}{T_B T_C} = 1 - \frac{N_C}{N_O}$$

$T_C = T_A + 6$, from which

$$\frac{T_A T_D}{T_B T_C} = \frac{60\,T_A}{54(T_A+6)} = 1 - \frac{1}{-300} = \frac{301}{300}$$

Simplifying,

$18000\,T_A - 16254\,T_A = 97524$

Therefore,

R = 56(integer) and

$T_C = T_A + 6 = 62$

Substituting these values in the above equation, we get

$$\frac{60 \times 56}{54 \times 62} = 1 - \frac{N_c}{N_o}$$

$$\frac{N_c}{N_o} = 1 - \frac{280}{279} = -\frac{1}{279}$$

Unless a change is permitted in the tooth numbers, this will be the best possible approximation.

By a method of trial and inspection, a closer result might be obtained. Thus, equal increments of all numbers of teeth will make small changes in the value of the fraction 280/279, yet without effecting the tooth differences. A few trials will enable one to gage immediately a suitable increment or increments. Thus, in the problem given, an increment of 2 will give the following result:

$$\frac{T_D T_A}{T_B T_C} = \frac{62 \times 58}{56 \times 64} = \frac{899}{896}$$

$$= 1 - \frac{1}{-299}$$

Hence,

$\frac{N_o}{N_c} = -299$, a figure very close to the desired —300.

So good an approximation will not always be possible, though unless two numbers be small, the error will never be great.

This procedure may not appear to be as simple as that of the original article, though, despite the necessity for trial work, it is actually less time-consuming, for it avoids the solution of a quadratic equation. Moreover, the method presented by Mr. Michael is only suitable where both the tooth differences are given, and is not at all applicable if the pairs of gears have different pitches.

The method I have set forth above may be applied equally well when the gears have different pitches. Thus, if in the above example the teeth in wheels B and D are six pitch, and in the wheels A and C five pitch, the difference between the pitch diameters of both pairs is obviously 1 in. The tooth difference for the six-pitch pair must therefore be 6 and for the five-pitch pair 5. The problem can then be solved proceeding as in the example given above.

DEFLECTIONS

MATERIALS RESPONSIBILITY

In a speech delivered before the National Association of Cost Accountants, Thomas R. Jones, vice-president of the Harris-Seybold-Potter Company, said that management does not control the factors entering into the budgeting of material directly but controls through the man who designs the product. That is a challenge to any engineer who is looking for opportunities to shift the blame for unprogressiveness. It is up to the engineer who designs a product to see that the best and most economic materials and units are incorporated; management puts it up squarely to him!

•

BRAINS FOR MACHINES

"Electric eyes" are being applied to an ever widening field of mechanical service, and their mechanism is coming to be called the "electric brain" of machines. The latest use is the attachment to conveyors to record the flow of material on a moving conveyor belt. Engineers will find an interesting study in these new light-control applications.

•

COOPERATION

Meandering around among firms during the Christmas days we found that at least one company has the good-will spirit all the year round. Here is the wording of a sign of greeting for salesmen calling at the Dexter Folder Company. It speaks for itself.

"We are always looking for products and methods that will enable us to make our own product a better one and more economical to manufacture. For that reason you are welcome here, and if we cannot give you an immediate hearing it is because someone else is before you. Our purchasing agent is Mr. James L. Crosbie. Please feel free to ask him to refer you to other department heads if you feel that it is desirable for you to see them."

•

NEW DESIGNS WILL SELL

Automotive people tell us that greater numbers of automobiles were junked in 1931 than were sold new. Such a condition of affairs, the first of its kind in the history of the industry, only means that tremendous reservoir of latent buyers is being built up for the time when money is a little freer. If there are enough outstanding new designs to make ridiculously antiquated the rest of the old cars in 1932, what a buying market will be ahead of us!

•

DEAD WEIGHT IN VEHICLES

In a paper recently given by Frank Jardine, chief engineer, Castings Division, Aluminum Company of America, it was shown that by carefully worked-out designs a weight saving of 28.5 per cent was made in an automobile chassis. Mr. Jardine also pointed out that in most vehicles total weight has been increased with every new design. The bus designers are now on the job to save dead weight haulage. The railways better watch out and redesign or the "bogie man" will get them. There is too much paid out for dead-weight haulage.

Maximum versus Minimum Pressures in Brake Bands

By L. D. HAGENBOOK

THE article on "Heat-Radiating Capacity of Clutches and Brakes" by Mr. A. C. Rasmussen, which appeared in the December number of *Product Engineering*, is a very valuable contribution to design data for large power clutches. The following comment is submitted as a discussion of that article.

Obviously the weak point of a clutch is its region of highest pressure. Here the brake material fails or wears rapidly because of two factors; first the temperature of the flange over which it is working, and, second, the force with which it is being pressed against this surface. The temperature of the flange is a function of the average work of slippage and is therefore proportional to M, the horsepower per sq.in. With a view to increasing the capacity of a clutch which is confined to a given space, it seems promising to make some correlation between the value of M and the ratio of maximum pressure to average pressure.

In considering a wrapping band clutch, the ratio of maximum pressure to average pressure, Q, is given by:

$$Q = \frac{u\ \theta\ e^{\theta u}}{e^{\theta u} - 1}$$

Where θ = radians of wrap
e = natural logarithm base
u = coefficient of friction

Expressed in terms of Mr. Rasmussen's article:

$$Q = 2\pi\, ku \left(\frac{T_1}{T_1 - T_2} \right)$$

This ratio for the band described in the article would be about 2.55.

Wear at the maximum pressure point, when the velocity of slippage is ignored, can be expressed by the relation:

$$(\text{Max. Pres.})^n \times (\text{Ave. Pres.}) = \text{Constant}$$

Observations on bands of widely different maximum pressure values would seem to indicate that the exponent n has a value somewhere between 1 and 2. In the absence of exact data on this point, a value of one seems to be a conservative figure. The average pressure allowable is therefore proportional to the square root of c divided by Q.

Evaluating the constant c from the band clutch, we have:

$$pA \propto \sqrt{\frac{2.55}{Q}} \propto M$$

The horsepower formula could therefore be revised to read:

$$HP = MA \sqrt{\frac{2.55}{Q}}$$

The use of this formula guards against overlooking the disastrous effects of local high-pressure points.

If the end castings to a band are improperly designed, the value of Q can become greater than 2.55. On the other hand, judicial proportions make it possible to lower Q and thereby increase the capacity of the clutch for a given space.

[*Editor's Note—In the second of Mr. Rasmussen's series on band brakes and clutches, appearing in this number, he shows how the unit pressures at different points in the band can be calculated. The above discussion is a valuable sequel to that article.*]

What Are Safe Loads on Worm Gears?

By E. K. AMBLER

VARIOUS empirical formulas have been given from time to time for the determination of safe loads on worm gear teeth. These maximum tooth loads will vary considerably with the pitch velocity of the worm. One engineer's handbook states that for continuous running, where heating and wear must be taken into consideration, allowable loads should be calculated by the equation:

$$W = c\, b\, p$$

In this equation b and p are the width of the tooth and the circular pitch respectively. The constant c should have about the following values for phosphor-bronze wheels and a hardened and polished steel worm running in an oil bath:

Peripheral velocity of worm, ft. per sec.	3.3	8.2	13.1	18.0	23.0
c	500	400	315	235	155

My experience indicates that these figures are extremely conservative if the gear is operated intermittently for not more than 1 min. with long intervals in between. Confining the discussion to peripheral velocities not greater than 8 ft. per sec., it appears to me that the allowable loads might be several times those calculated using the above formula.

In one instance that I know of, a wormwheel with 1¼ in. pitch and 3 in. face width has successfully withstood a tooth load of 2,500 lb. in intermittent service, the worm making 600 r.p.m. for about 10 sec. at 15 min. intervals. This corresponds to a peripheral velocity of about 7½ ft. per sec. Yet on the basis of the above equation, the maximum allowable tooth load would be less than 1,500 lb.

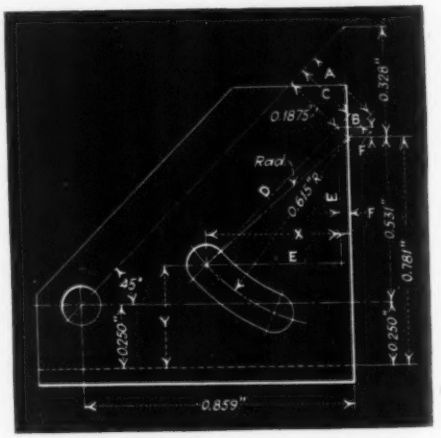
I would be very much interested in learning something about the experience of other engineers on this problem.

The Last Solutions

UNFORTUNATELY, the incorrect location of the arrowhead designating the radius of the center line of the slot caused some of the readers who answered the problem "What Is the Answer?" that appeared in the October number, to obtain erroneous results. However, it is interesting to note that almost all had discovered the error in the drawing by analysis.

Mr. C. A. Wiken, whose solution appeared in the December number, shows that by using the correct radius for the center line of the slot, the answer for x would be 0.4651 and for y 0.3787. In bringing this problem to a close, the three following solutions are given. Space does not permit publication of the numerous additional solutions submitted.

SOLUTION BY J. MASLINE
Designer, The Hoover Company



Referring to the accompanying figure, the solution of the problem is as follows:

A = 0.328 sin 45 deg.
= 0.328 × 0.7011 = 0.23193
B = 0.23193 — C = 0.04443

$C = 0.1875$

$D = \sqrt{Rad^2. - B^2} = 0.61339$

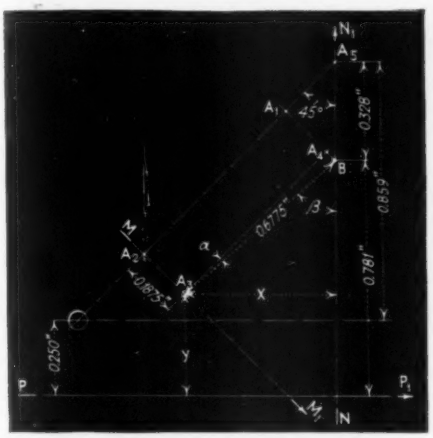
$E = D \sin 45 \text{ deg.} = 0.61339 \times 0.70711 = 0.43373$

$F = B \sin 45 \text{ deg.} = 0.4443 \times 0.70711 = 0.031417$

$X = E + F = 0.43373 + 0.031417 = 0.465147$

$Y = (0.781 + F) - E = 0.781 + 0.031417 - 0.43373 = 0.378687$

SOLUTION BY HENRY F. J. SKARBEK



Using the projection method, and referring to the accompanying figures, we have for the projections upon the line M-M_1.

$A_2A_3 + A_4B = A_1B$

$0.1875 + 0.6775 \sin \alpha = 0.328 \cos 45$

$$\sin \alpha = \frac{0.328 \cos 45 - 0.1875}{0.6775}$$

$$\alpha = 3° - 45' - 58''$$

Projecting upon the vertical line NN_1 in the direction as indicated by the arrow, we have:

$y + 0.6775 \cos \beta = 0.781$

$y = 0.3343$

Projecting on the line PP_1 in the direction as indicated by the arrow, we have:

$X = 0.6775 \sin \beta$

$X = 0.5095$

The sketch as presented in the problem is evidently in error in that the radius should have extended to the center line of the slot. That is, in the above calculation the dimension 0.6775 should have been 0.615. However, the figures as given were used in this calculation.

ALFRED ZUGEHOER

The answers to this problem, using analytical geometry methods, are:

$x = 0.4768$

$y = 0.3674$

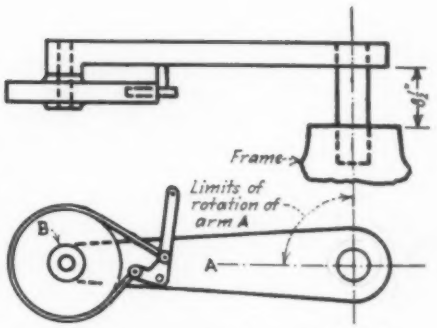
How Can It Be Done?

By J. A. COVINGTON

IN the design of a special machine, I am confronted with a sticky little problem on the actuation of a brake. As shown in the accompanying diagram, the brake drum B is mounted on an arm A that has a limited rotation of $\frac{1}{4}$ of a revolution about the shaft S. Some simple means must be provided for actuating the brake.

For various reasons, it is impossible to use a hollow shaft. It must be possible to either apply or release the brake when the arm is in any position in its quadrant. Finally, whatever linkage or mechanism is used must not occupy more than $8\frac{1}{2}$ in. of shaft length, as indicated in the drawing.

I would appreciate receiving ideas from the readers of *Product Engineering* on the solution of this little problem. I have succeeded in working out a rather complicated linkage, but feel that the same result can be accomplished in a manner that will require fewer parts.



Simple means must be provided for actuating the brake mounted on the arm A which rotates through $\frac{1}{4}$ of a revolution

Plenty of Advice But No Action

By H. F. WILLIAMSON

ENGINEERS attending meetings of their professional society are frequently told that for the advancement of their profession and the public welfare, the engineer should take an active part in the conduct of our government. Officers and others who take leading parts in technical societies seem prone to harp on the apparent indifference of engineers toward political matters.

Individual action in public affairs of importance is futile, and usually results in ridicule. Without the backing of a powerful organization, a reform movement or new legislation is doomed to a quick demise. In the light of this, it seems strange that the various engineering societies, as organizations, have not even attempted to practice what their leaders so ardently preach. Only in isolated cases, and usually as an independent action of a local section of the parent society, have these associations participated in public affairs.

Right in the city where is located the headquarters of our largest engineering societies, is plenty of material to work on. The absurd truck specifications of the Sanitary Commission of the City of New York is merely one of a great number of deals that calls for engineering attention. In national affairs, patent protection has become almost a joke, thanks to the legal profession and judges who know worse than nothing about engineering fundamentals. Countless other instances could be cited. Yet our engineering organizations have done nothing.

Why have not our great engineering societies followed the examples of the medical and legal professions? Do we lack the leadership? Are those who loudly preach engineering leadership themselves incapable of stirring the societies to action? If so, they might as well stop preaching.

If engineering societies are to obtain proper recognition for the profession, they must, as organizations, take an active part in the conduct of our government in matters concerning the engineering profession. Let the answer of the individual members to the exhortations of the past be a demand that the necessary machinery for the participation of their societies in public questions affecting the welfare of the business and profession of engineering, be established immediately. Put engineering on the same plane with law and medicine, and thus raise the income of engineers.

Engineers are fundamentally no different from other people. The reason so few of them take an active part in civic affairs is simply because there is no natural channel available that will steer them in that direction. Were it made possible to combine professional activities with political affairs through the medium of a strong professional organization, many engineers would be glad to take advantage of the opportunity to participate in public affairs.

NEWS

Steel Founders, A.S.T.M., Mechanical Engineers Will Meet—Coming Exhibits—Relief of Unemployment

AS THIS number goes to press, the Steel Founders Society of America, Inc., is holding its annual meeting at the Stevens Hotel, Chicago. W. H. WORRILOW, president of Lebanon (Pa.) Steel Foundry and of the society expressed as his profound belief that a trade association's worth depends upon the activity of all its members, not upon the strenuous efforts of a few. He stressed the need for adhering to the Society's uniform cost system, for opening new markets and expanding research, and for continuing publicity and advertising.

The annual report of the managing director, GRANVILLE P. ROGERS, had been mailed to members previous to the meeting. It showed an increase of membership from 48 in 1929 to 78 in 1930 and 84 in 1931 at the year's high. In his verbal presentation of the report at the meeting, Mr. Rogers explained the present need for more concentrated research and development in order that industry may be ready when business begins its return to normal.

A symposium on steel castings will be an important element of the 1932 annual meeting of the American Society for Testing Materials in Atlantic City. The symposium, sponsored jointly by the A.S.T.M. and the A.F.A., is the second thus sponsored, the first, at the 1931 annual meeting, being on malleable castings. Plans for the program include a general survey of the steel castings industry, principles of casting design as related to physical properties, soundness, and ease of production; test-bar specifications, and a number of related engineering and production subjects, including fields of application governed by various physical properties, development of various types of alloy steels for castings, and welding of castings.

The A.S.M.E. has definitely announced Bigwin Inn, Lake of Bays, Ont., Canada, as the meeting place for the summer meeting, June 27-July 1. The technical program has not yet been announced. The Applied Mechanics Division of the Society will meet at Yale University, New Haven, Conn., June 23-25, with the American Physical Society. A feature is the intention to set aside one complete session for purely informal discussions of existing problems, in order to increase the value of the meeting to the designing engineer.

The American Engineering Council, at its annual meeting in Washington Jan. 14-16, took steps to align the engineering profession in support of legislation to create an Administration of Public Works, in accordance with the recommendation of President Hoover in his last message to Congress. First action following this decision will be to support the Cochran Bill, which provides for creation of such an Administration and more effective cooperation of public works functions of the government. Among amendments to the Bill which engineers will press will be one to permit employment of private engineers on government projects. WILLIAM S. LEE of Charlotte, N.C., A.I.E.E. past president, was elected council president.

Total exhibitors for the National Aircraft Show for 1932, scheduled in Detroit April 2-10, thus far number 33, according to Ray Cooper, manager of the show, which will be sponsored by Aeronautical Chamber of Commerce of America, Inc. The Exposition will be held at Detroit City Airport, in charge of a committee headed by WILLIAM B. MAYO, chief engineer of Ford Motor Co.

The National Machine Tool Builders Association has scheduled its third machine tool show for Cleveland, Sept. 10-17 of this year. Allotments of 61,000 sq.ft. of floor space in Cleveland Municipal Auditorium, have already been made, indicating that the show will be at least as large as the last one, held in 1929.

Some 3,500 French and foreign manufacturers, including those of 24 foreign countries, will have exhibits at the next Lyons International Fair, March 7-20, including 625 stands, displaying metallurgical products, machinery, tools, engines, motors, hardware, and industrial equipment; and 265 displaying electrical equipment and radio installations.

A two-day clinic on packaging technique and a day's discussion of consumer marketing will be followed by two days devoted to the problems of packing and shipping and a day's program on the subject of production management at the Second Packaging, Packing and Shipping Exposition and Conference to be held at the Palmer House, Chicago, March 7-12, under auspices of the A.M.A.

The next Leipzig Trade Fair is to be held March 6 to 12, with some 9,000 industrial products of twenty-five countries on display. In an effort to stimulate American trade and to get American buyers to attend, the Fair management is offering free transportation to those who buy a given amount there.

Representatives of 62 companies engaged in the manufacture of materials handling equipment met recently at the Hollenden Hotel, Cleveland, and established the Materials Handling Institute. These officers were elected: president, FRANK E. MOORE, president, Mathews Conveyor Co., vice-president, J. B. WEBB, president, J. B. Webb Co., treasurer, H. W. STANDART, Northern Engineering Works; and secretary, JOHN A. CRONIN, editor, *Materials Handling and Distribution.*

Considerable work has been done during the past month in the effort to find work for unemployed professional engineers. The committee formed for that purpose by the engineering societies has found work for half of the unemployed in the New York area, and 90 per cent are expected to be placed by the end of this month. Thus far 1,200 men have registered in New York at committee headquarters . . . P. H. DAGGETT, dean of Rutgers University, has also advanced a plan for employing engineers for research work in colleges, starting the ball rolling by employing six at his own institution.

Metal Markets

COPPER prices became firmer and advanced to 7½c. during December and early January after it was announced that producers had reached an agreement on curtailment of production. According to *Metal and Mineral Markets,* the agreement of Copper Exporters, Inc., will be sent to the European associates for action toward the end of January. Meantime, temporary rules are in effect regarding export price and sales quotas. Fabricators reported a moderate gain in orders following the increase in the price of the metal, but it is too early to report the real effects of the advance.

ZINC prices, on the other hand, eased off, sinking to 3.05c. St. Louis basis, a new low for this metal. Lack of demand was given as the chief reason for the decline, although the tonnage sold early in January was large compared with that of recent weeks.

LEAD sales have been better in January than for the past two months, and the price has remained unchanged at 3.75c., New York. It is thought that this price will remain stable unless a rush of new business should come in. November production of lead showed a gain from that of the previous two months. Babbitt metals for machine bearings, however, hit a new low in November, which would naturally react on the lead and tin markets. The total production of lead for 1931 was 32 per cent lower than for the previous year.

TIN markets gained in strength during early January. The price Jan. 12 for prompt Chinese tin was 21.225c. An additional curtailment of 10 per cent in production was put into effect on Jan. 1 by the governments participating in the tin pool.

SILVER production went down 20 per cent in 1931 after two years of steadily receding prices. This metal is being used to an increasing extent in solders and brazing metals.

BERYLLIUM is now being sold in the form of beryllium-copper ingots, containing 12.5 per cent of Be. The price is steady at $6.35 per lb.

Standards and Specifications

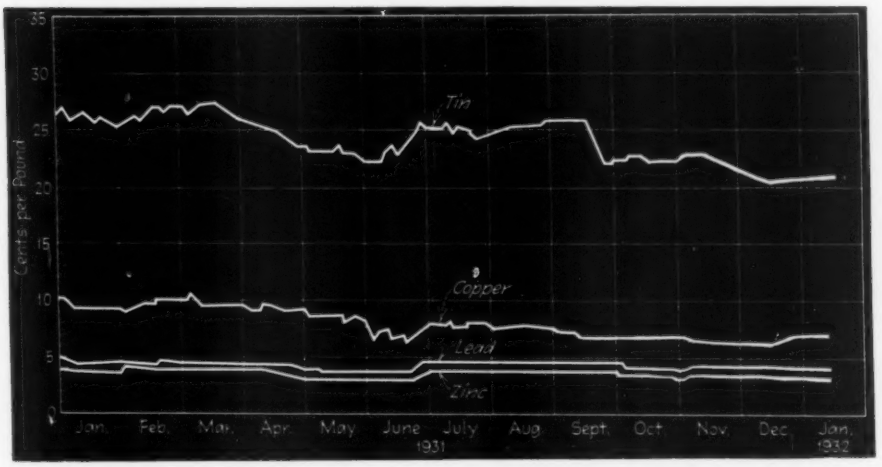
The proposed American tentative standard for lock washers has been rereleased by the subcommittee which developed it, and is now being circulated to industry for general criticism and comment. It is sponsored by the A.S.M.E. and the S.A.E. and was developed under A.S.A. procedure. The proposal contains a table of dimensions for lock washers (spring washers) giving the nominal size, actual inside diameter, dimensions for washers for use with wrench head bolts and nuts, and slotted head screws. Copies are obtainable from C. B. LePage, assistant secretary, A.S.M.E., 29 West 39th St., N. Y.

A proposal for an American Standard for manhole frames and covers containing recommendations for 13 types of frames and seven types of covers has been published by the A.S.A.

A number of foreign standards and specifications are available to A.S.A. sustaining members for loan or purchase. This list will henceforth appear monthly in the *Bulletin.* More than 10,000 standards are available, including a number on metals machinery and equipment. New standards received include several on mechanical testing by various methods (Austria), pipe fittings and flanges (Czechoslovakia), bolt holes, bright round washers, castellated nuts, hexagon nuts, and three on various types of hinges (Denmark).

The A.S.T.M. has issued a booklet, "The Economic Significance of Specifications for Materials," containing six papers giving the point of view of steel manufacturer and user, concrete producer and user, large purchaser of engineering and special materials, and a general discussion on motor oils.

A proposed revision for Federal Specification No. 370, on Manganese Bronze Castings, is being submitted to industry for criticism and comment under No. QQ-B-726. QQ-F-201 will supersede Federal Specification No. 135, on Ferrovanadium. QQ-B-601 will supersede No. 286 on Brass Castings to be Brazed. QQ-W-401 will supersede No. 532 on Phosphor-Bronze Spring Wire. QQ-S-571 will supersed F.S. No. 313 on Tin-Lead Solder, and QQ-S-566 will supersede No. 306 on Spelter Solder for Brazing.



Meetings

Society of Automotive Engineers—Annual meeting, Book-Cadillac Hotel, Detroit, Mich., Jan. 25-29. John A. C. Warner, secretary, 29 West 39th St., New York.

American Institute of Electrical Engineers—Annual Winter meeting, Engineering Societies Bldg., New York, N. Y., Jan. 25-29. F. L. Hutchinson, secretary, 33 West 39th St., New York City.

Second International Heating & Ventilating Exposition—At Cleveland Municipal Auditorium in connection with annual convention of the American Society of Heating & Ventilating Engineers and joint meeting with American Society of Refrigerating Engineers at the Hotel Cleveland, Cleveland, Ohio, Jan. 26-29, 1932. Secretary, David L. Fiske, 37 West 39th St., New York City.

National Automobile Show—Chicago, Coliseum, Jan. 30-Feb. 6.

British Industries Fair—Castle Bromwich, Birmingham; and White City and Olympia, London, England, Feb. 22-Mar. 5. Displays and exhibits will cover all sorts of equipment and machinery, both for industrial and domestic use.

American Management Association—Packaging, packing, and shipping exposition, Palmer House, Chicago, Ill., Mar. 7-12, 1932. W. J. Donald, managing director, Room 602, 225 West 64th St., New York, N. Y.

American Society of Bakery Engineers—Annual meeting, Edgewater Beach Hotel, Chicago, Mar. 14-17. Includes exhibits of bakery machinery. Victor E. Marx, secretary, 1541 Birchwood Ave., Chicago.

American Railway Engrg'g Ass'n—Annual meeting, Palmer House, Chicago, Ill., Mar. 15-17. E. H. Fritch, secretary, 59 East Van Buren St., Chicago.

Knitting Arts Exposition—28th annual show of textile machinery, Commercial Museum, Philadelphia, Pa. April 11-15.

American Oil Burner Ass'n—Annual meeting and exposition, Boston, Mass., April 11-15. Harry F. Tapp, secretary, 342 Madison Ave., New York City.

Electrochemical Society—Spring meeting, Baltimore, Md., April 21-23. Colin G. Fink, secretary, Columbia University, New York City.

American Foundrymen's Ass'n—36th annual convention and exhibition, new Municipal Convention Hall, Philadelphia, Pa., May 2-6. Executive secretary, 222 West Adams St., Chicago.

Engineers and their Activities

C. E. MacQuigg

H. W. Gillett

L. W. Spring

COL. C. E. MACQUIGG, manager of Union Carbide & Carbon Research Laboratories, Inc., Long Island City, New York, spoke Jan. 20 before The Franklin Institute in Philadelphia on "Research and Development in Metallurgy." H. M. WILCOX, vice-president, Electrical Research Products, Inc., a subsidiary of Western Electric, New York City, will speak on the "Development and Use of Talking Motion Pictures" on March 31.

DR. H. W. GILLETT, director of Battelle Memorial Institute, Columbus, Ohio, and L. W. SPRING, chief chemist and metallurgist, Crane Co., Chicago, will be presented the W. H. MacFadden and the John A. Penton gold medal awards of the American Foundrymen's Association for outstanding service to the foundry industry. These two medal awards will be presented at the 1932 convention of the A.S.A. at Philadelphia in May and are two of the four awards established through grants of funds by past officers in 1920.

FRED H. COLVIN, editor of *American Machinist* and consulting editor of *Product Engineering*, has been made a member of the Production Activity Committee for 1932 of the Society of Automotive Engineers. Mr. Colvin has been connected with *American Machinist* for the last 25 years.

L. M. DETURK, designing engineer in the autocar division, J. G. Brill Co., Philadelphia, Pa., has been advanced to experimental engineer of the company.

A. S. GENTLES and A. G. LANGLEY have been elected president and vice-president of the Association of Professional Engineers of British Columbia. Mr. Gentles is manager of the Dominion Bridge Co. plant at Vancouver, and Mr. Langley is a consulting engineer in Vancouver.

DR. O. C. BRIDGEMAN, who has done extensive work in cooperative fuel research, has been appointed chief of the friction and lubrication section, Bureau of Standards, City of Washington.

BANCROFT GHERARDI, vice-president of the American Telephone & Telegraph Co., has been re-elected president of the American Standards Association for 1932. Other officers, also re-elected, include: CLOYD M. CHAPMAN, consulting engineer, United Engineers & Constructors, Inc., who is vice-president of the association and chairman of the A.S.A. Standards Council, and JOHN C. PARKER, of the Brooklyn Edison Co., vice-chairman of the Standards Council.

HAROLD ADAMS BACKUS has become an experimental engineer with Pitcairn Aircraft, Inc., Willow Grove, Pa. He was formerly superintendent of Metallurgical Laboratories, Inc., Philadelphia.

PROF. ERNEST BROWN, formerly professor of mechanics and hydraulics at McGill University, Montreal, has been appointed dean of the Faculty of Engineering there. Professor Brown has been for some time connected with the Shawinigan Water & Power Co. on hydraulic work.

H. J. FRENCH, since 1929 a member of the International Nickel Co. research staff at its laboratory in Bayonne, N. J., has been transferred to the development and research department in New York to take charge of development work in steel and iron. He was senior metallurgist at the U. S. Bureau of Standards before joining International Nickel and was awarded in 1930 the Henry M. Howe Medal of the A.S.S.T.

LOUIS A. GILMER, formerly mechanical engineer with International Engineering Corp., Chicago, has become a designing engineer on Diesel engines with I. P. Morris & De La Vergne, Inc., of Philadelphia.

HALL L. HIBBARD, formerly project engineer of Stearman Aircraft Co., Wichita, Kan., has become supervising engineer with Stearman-Varney, Inc., Alameda, Calif.

NAN HORNBECK, consultant on industrial color and one of the experts who contributed to the discussion of color in *Product Engineering* last month, will speak on "Glorify Your Product With Color" to the management division, A.S.M.E., in New York, Feb. 3.

ELMER P. JASPER, formerly chief engineer of the motor division, Chris Craft Corp., Algona, Mich., has been appointed chief engineer and plant superintendent of Lodge Motors, Inc., Detroit.

PROF. A. B. LAMB of Harvard University has been elected president of the American Chemical Society for 1933. The president for 1932 is DR. L. V. REDMAN, vice-president and director of research of the Bakelite Corp., Bloomfield, N. J., who succeeded PROF. MOSES GOMBERG of the University of Michigan, Jan. 1.

J. T. LANSING, formerly manager of the sales-promotion department, United American Bosch Corp., Long Island City, N. Y., has joined the engineering department of Scintilla Magneto Co., Inc., Sidney, N. Y.

A. D. MOSBY, chief engineer and plant manager, Construction Machinery Co., Waterloo, Iowa, has been advanced to vice-president and will be in direct charge of production.

CARL A. PETERSON, formerly designing engineer for the Atwood-Bradshaw Corp., Pittsburgh, has been made chief engineer and a director.

EVERETT S. LEE, an assistant engineer of the General Engineering Laboratory, General Electric Co., has been appointed engineer of the laboratory to succeed the late LOUIS T. ROBINSON. He has been with General Electric intermittently since 1913 and an assistant engineer since 1928. DR. J. J. SMITH will succeed Mr. Lee as one of the assistant engineers of the laboratory.

JUAN DE LA CIERVA and HAROLD F. PITCAIRN were jointly awarded a John Scott medal for "useful inventions" by the City of Philadelphia. The award was made for invention and development of the autogiro and was made by DR. LOUIS HEILAND, secretary of the board, on Jan. 15. It carries with it a premium of $1,000.

W. S. PRITCHARD, formerly factory manager of the Detroit Aircraft Corp., has become development engineer for Doehler Die Casting Co., Toledo, Ohio.

S. W. PLACE, formerly with the Atwater Kent Design Laboratories, has joined the research department, Synthane Corp., Oaks, Pa.

DR. HARVEY C. RENTSCHLER, director of research, Westinghouse Lamp Co., spoke on "Scientific Conquests of 1931" at the Jan. 13 Science Forum of the New York Electrical Society. He outlined the year's advances in bacteriology, physics, cosmic rays, chemistry, engineering, astronomy, and other sciences.

ARTHUR R. SCHULZE, formerly assistant chief engineer, Mingo works, Carnegie Steel Co., has been appointed chief engineer of the Ohio works at Youngstown.

HARRY G. SMITH, formerly chassis engineer with Studebaker Corp., South Bend, Ind., has become a designer with the Buick Motor Co., Flint, Mich.

DAVID T. SICKLESTEEL has rejoined Detroit (Mich.) Gear & Machine Co. as experimental and development engineer. This previous connection was with the engineering staff of Muncie (Ind.) Products Division, General Motors Corp.

J. SLEPAIN has been asked to present a technical paper on "Interruptions of Power Arcs" at the International Electrical Congress, in Paris, France, in June of this year. Three other engineers of the Westinghouse Electric & Mfg. Co. will also present papers at the congress. C. L. FORTESCUE will discuss "Lightning and Its Effects," and R. D. EVANS and C. WAGNER will discuss "Stability of Power Systems" together. Such a congress was held in 1881.

DR. F. C. STANLEY, chief engineer of the Raybestos Division, Raybestos-Manhattan, Inc., Bridgeport, Conn., spoke recently at a meeting of the Northern California Section, S.A.E., on truck and tractor brake problems and on free wheeling and its influence on brake performance.

Everett S. Lee

Juan de la Cierva

Harold F. Pitcairn

H. P. CHARLESWORTH, vice-president of the Bell Telephone Laboratories, has been nominated for president of the American Institute of Electrical Engineers. He will be voted on this Spring at the regular meeting.

HERMAN STOLL, formerly chief draftsman for Adam Opel, A.G., Russelheim, Germany, has returned to this country and is now doing research work in the engineering department, Chevrolet Motor Co., Detroit, Mich.

RALPH H. UPSON, who has been engaged for some time in the development of a novel airplane-flying instrument which will combine the functions of several present instruments, is associated with Automotive Fan & Bearing Co., Jackson, Mich. After his design work in 1926 and 1927 on the experimental metalclad ZMC-2 airship built for the Navy by Aircraft Development Co., Detroit, Mr. Upson was engaged in aeronautic engineering with Aeromarine Klemm Corp., Keyport, N. J., in 1929. He spent the last two years in development work on a new type of airplane and the new airplane instrument at Stout Engineering Laboratories, Dearborn, Mich. Result of this recent work are approaching the stage of commercial production.

HAROLD W. BIBBER left the central station engineering department, General Electric Co., Schenectady, N. Y., Jan. 1, to become associate professor of electrical engineering, Ohio State University.

G. B. WARREN has been appointed designing engineer of the steam turbine section, and M. A. SAVAGE designing engineer of the steam turbine generator section, General Electric Co. J. H. DORAN has been appointed assistant on mechanical design for the turbine engineering department, and W. E. BLOWNEY, administrative assistant in the same department.

T. E. WELTON, mechanical engineer, and R. B. KOONTZ, engineer and executive for many years with Adamson Machine Co., Akron, Ohio, will be vice-president and secretary-treasurer respectively of the Patterson Engineering Corp., affiliated with Patterson Foundry & Machine Co., recently formed with offices at 414 United Bldg., Akron, Ohio. The company has been organized to manufacture specialized rubber machinery as designed and perfected by Mr. Welton. R. L. CAWOOD, president of Patterson Foundry & Machine, will also be president of the new company.

OSCAR WERNER has become a development engineer with William Gent Mfg. Co., Cleveland, Ohio.

HERBERT S. WHITON has been appointed chief mechanical engineer of the Byllesby Engineering & Management Corp.

T. H. WICKENDEN, since 1922 in charge of development work in automotive and aeronautical fields for International Nickel Co., Inc., has been appointed assistant manager of development and research. Following graduation from school, he became metallurgist for Studebaker Corp., which in due course put him in charge of the engineering department at the South Bend, Ind., plant. Later he was one of the engineering group which designed the first Chrysler car.

ERIC WISBRUN, formerly research engineer, Perfect Circle Co., Newcastle, Ind., has been placed in charge of the chemical and physical laboratory, Liberty Foundries Co., Rockford, Ill.

MATERIALS AND PARTS

Carpenter Stainless No. 8

A free-machining 18-8 stainless steel has been announced by The Carpenter Steel Co., 117 W. Bern St., Reading, Pa., to supplement stainless No. 5 chrome iron. The corrosion-resistance of this high-sulphur stainless No. 8 is about the same as the low-sulphur stainless No. 4 and may be used interchangeably. The choice between them lies chiefly in the manner in which the parts are to be fabricated. The Carpenter stainless No. 8 is offered for parts that must be machined and the stainless No. 4 for parts that are bent, drawn or formed to shape.

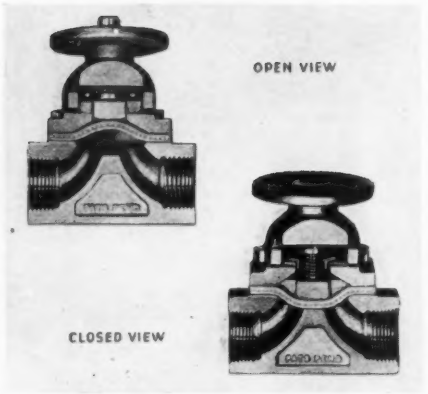
A comparison of physical properties of stainless No. 8 as against stainless No. 4, both 18-8 compositions, is given below:

	(Carpenter Stainless No. 4)	(Carpenter Stainless No. 8)
	Hot-rolled,	Unannealed
Tensile strength, lb. per sq.in.	100,000	100,000
Elastic limit, lb. per sq.in...	50,000	50,000
Elongation in 2 in., per cent	50	45
Reduction in area, per cent..	65	56
Izod impact, ft.-lb.....	100	70
	Annealed at 1,825 Deg. F.	
Tensile strength, lb. per sq.in.	95,000	95,000
Elastic limit, lb. per sq.in...	35,000	33,000
Elongation in 2 in., per cent	57	53
Reduction of area, per cent..	71	58
Izod impact, ft.-lb.....	110	50

There is no corrosive galvanic action between "free-machining" 18-8 and standard type of 18-8 when used together in the same assembly.

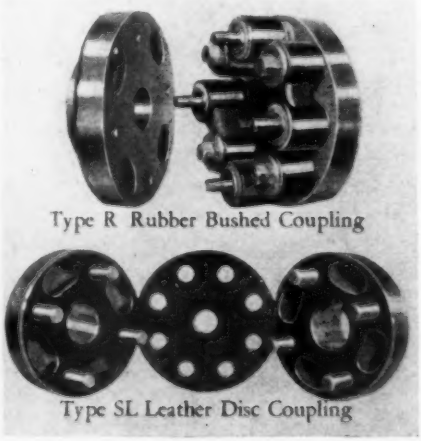
Hills-McCanna Diaphragm-Type Valve

The Hills-McCanna Co., 2349 Nelson St., Chicago, Ill., has acquired manufacturing and sales rights on a valve which has no metal-to-metal seats, no stem packing or stuffing boxes, and is recommended for general service. The materials handled do not reach the valve bonnet. The diaphragm protects all the working parts from the substances handled. This is of value when handling volatile liquids, gases and air, liquids having gritty solids in suspension and corrosive liquids. Access to the body or the bonnet does not require removal from the line. In the closed position the diaphragm is compressed between the compressor follower and the seat. An even distribution of pressure on the diaphragm is secured.



"F.A.B." Flexible Couplings

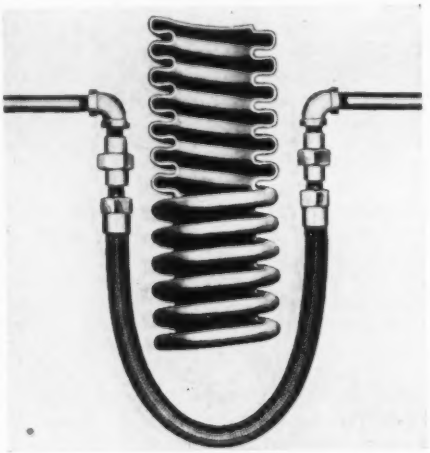
A shock-resisting feature and a method of eliminating vibration are embodied in the flexible couplings developed by the F. A. B. Mfg. Co., 67th & Vallejo Sts., Oakland, Calif. These features are in addition to those compensating for parallel and angular misalignment, or combinations of both. No lubrication is required for these couplings, and they will operate at speeds up to 3,450 r.p.m. without noise. Sizes are manufactured for transmitting up to 1,200 hp.


Type R Rubber Bushed Coupling

Type SL Leather Disc Coupling

Bendix Seamless Flexible Metallic Tubing

Seamless, flexible metallic tubing is being offered by the Bendix Stromberg Carburetor Co., subsidiary of the Bendix Aviation Corp., South Bend, Ind. The hose, manufactured in internal diameters of $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in., will withstand temperatures of over 500 deg. F., and pressures of over 10,000 lb. per sq.in. General applications are fluid connections between moving parts with absorption of vibration, and conveyance of liquids, semi-liquids, steam or gas.



The hose is seamless, and the fittings are brazed or welded to the hose to prevent leaks. Made of a special bronze alloy seamless pipe, the hose is corrugated in a round-thread single lead, deep wall form. The deep wall construction adds to the flexibility. A protective casing, braided from copper, is designed to cover the hose with either one, two or three layers, depending upon the pressure that the hose must withstand. As a protec-

tion against the mechanical damage to the braid covering and to distribute the flexing action, the manufacturer recommends the use of an interlocked, unpacked galvanized steel casing over all.

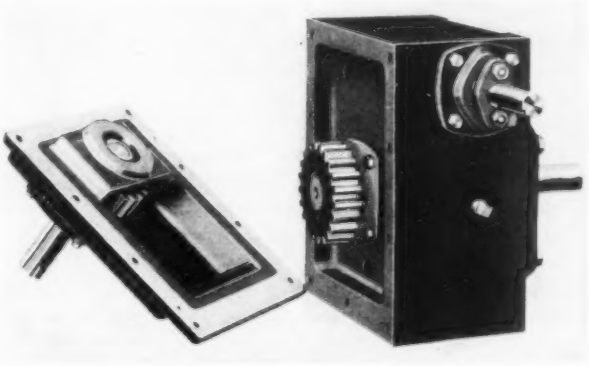
Allen Chrome-Molybdenum Hollow Screws

Large gains in tensile strength and hardness of its hollow screws have been secured by The Allen Mfg. Co., Hartford, Conn., by the substitution of a chrome-molybdenum steel for the steel formerly employed. The tensile strength of these screws is now 50 per cent greater and the Rockwell hardness has been increased 25 per cent. The screws are available in all sizes commonly used. They are milled from the bar with cut threads. These screws are now in stock with the company's jobbers.

Ohio Two-Speed Reversing Unit

The Ohio Gear Co., 1333 E. 179th St., Cleveland, Ohio, has announced a two-speed reversing unit. When this unit is used as a substitute for bevel gear reversing, it permits the clutch to be placed where most convenient, instead of between the two ends of the shafts, where, as a rule, there is little room to spare. The two speeds may be arranged for 1:1 ratio or any other reasonable ratio likely to be met with. Furthermore, the shaft may be arranged to be on opposite sides of the housing or on the same side, and to operate in the same or in opposite directions. All gear teeth are permanently in mesh to avoid undue wear.

The unit can be arranged to operate shafts whose centers are several inches apart. If a Hookes joint or similar device is added it also operates shafts which are out of line as well as out of center. Being completely inclosed, the reversing unit is dust and moisture proof. The ball bearings are grease lubricated.



Open view showing rigid construction for shaft bearings and oil passages

Reeves Inclosed Vertical Transmission

For installations requiring an inclosed variable-speed drive of small floor space, the Reeves Pulley Co., Columbus, Indiana, is introducing a vertical inclosed transmission which incorporates the standard internal operating parts of the Reeves variable speed drive. The side of the housing may be removed by means of four capscrews, and the lid may also be removed for inspection of the internal operating parts or minor adjustments. U-shaped recesses in the other section of the case permit removal of the entire operating parts.

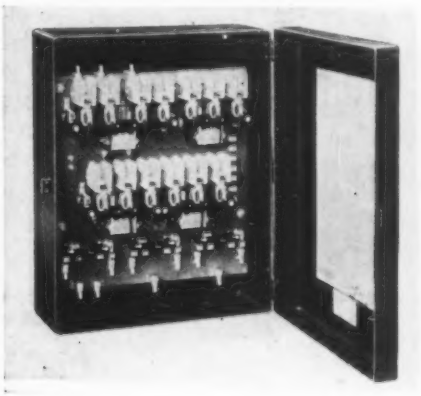
A feature of the vertical inclosed design is the convenience in lubrication facilities. All shaft and thrust

bearings are lubricated through force-feed fittings located in two convenient exterior panels. Shafts, driving keys and disk hubs are lubricated by means of force-feed fittings in each end of the shaft extensions.

This transmission may be equipped with electric remote, electric automatic, and mechanical automatic controls, and with motors, motor bases and other accessories for varying requirements of speed control. The motor rails and motor may be mounted either in connection with the pivoting motor base, or on the side of the transmission. This transmission is available in ten sizes covering speed ratios of from 2:1 to 8:1 inclusive.

Allen-Bradley Automatic Switches for Multi-Speed Motors

Bulletin 715 automatic, multi-speed, across-the-line switches have been developed by the Allen-Bradley Co., 1311 South First St., Milwaukee, Wis. These switches are for two-, three- or four-speed, non-reversing service, in connection with two- and three-phase, multi-speed



motors of consequent-pole-winding or separate-winding type, in ratings up to 40 hp., 220 volts, and 75 hp., 440-550 volts, 25 to 60 cycles.

Protection against overloads is provided through the use of thermal overload relays for each speed. No-voltage protection is a standard feature with three-wire control, and no-voltage release with two-wire control.

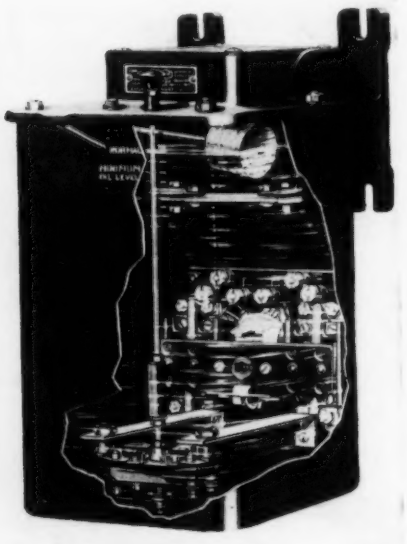
"Lubriplate" Greases and Oils

Plating a minute zinc film on bearing surfaces is one of the features of "Lubriplate" oils and greases announced by the Lubriplate Corp., 3114 Chrysler Bldg., 405 Lexington Ave., New York, N. Y. Defects and tool marks in the metal are filled up with the zinc plating, but the plating is not increased to a point where it disturbs the fit. Thus, Lubriplate not only gives a better bearing surface

but prevents rust and corrosion. Lubriplate is nearly white in color and is not subject to discoloration with use, it is claimed. It is offered in a full range of oils for light and heavy-duty operation and also greases.

Cutler-Hammer Across-the-Line A.C. Starter

An explosion-proof, across-the-line, automatic starter for a.c. squirrel cage induction motors is announced by Cutler-Hammer, Inc., 205 No. 12th St., Milwaukee, Wis. Distinguishing this starter from similar explosion-proof equipment is the immersion in



oil of its new thermal overload mechanism. It differs from the usual immersed oil dashpot relay and three-pole magnetic contactor in that a newly designed thermal overload mechanism is used with the contactor.

"Apex" 400 Alloy

Owing to the confusion that has arisen in the use of the name "Perm-Brite" with other somewhat similar trade names in the non-ferrous industry, the Apex Smelting Co., 2554 Fillmore St., Chicago, has discontinued the use of this name and will call this aluminum alloy "Apex 400 Alloy." Perm-Brite was originally described in the June, 1931, issue of *Product Engineering*.

The specific gravity of Apex 400 Alloy is under that of pure aluminum. It is non-corrodible in atmosphere, sea water and various acids. The metal is extremely ductile and has an elongation up to 23 per cent in 2 in. in the rolled state. Machining properties are good and the metal can be welded autogenously and the welds dressed and hammered when cold. Welded seams offer practically the same strength as the parent metal.

The company offers the alloy for cooking utensils, carburetors, bus seats, marine castings, fire-fighting equipment, and hospital apparatus.

Rockwood Improved Short-Center Drive

Several improvements have been made by the Rockwood Mfg. Co., Chicago, Ill., in its short-center drive. The base is now equipped with adjustable arms for the motor, and the drive is now adaptable to all kinds of motors built for 25, 50 or 60 cycles, single or polyphase, a.c. or d.c. This feature of adjustable motor-arm brackets permits minimized wear on the pulley-end motor bearing, and gives means for securing the correct belt tension so that the life of the belt is increased. In addition, the power consumption is only that required by the driven machine.

When the base is shipped, it is assembled so that the motor bracket is directly over the center line of the

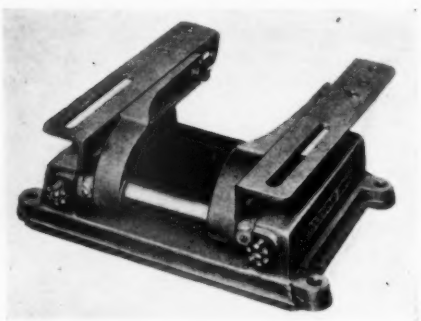


Fig. 1—Adjustable arms permit use of any commercial motor

base, but Fig. 2 shows the bracket displaced so as to move the motor away from the center line. When installed the base is located in position dictated by the desired center distance, and the pivot shaft moved away from the end of the base and the adjustable arms moved one-third of the distance outward away from the pivot shaft. Thus, there is ample room for any movement of the motor to increase or decrease the amount of the motor weight used as belt tension. After the drive has run a while the pulleys can be checked for belt slippage.

Should the bearing pressure be too high so that the motor bearings run hot, the motor can be adjusted back-

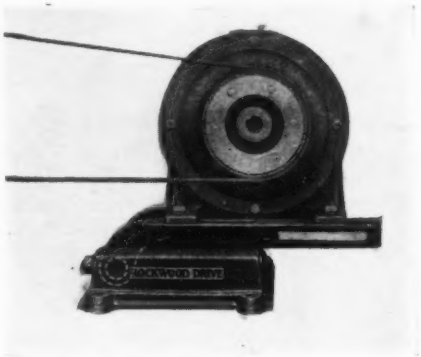


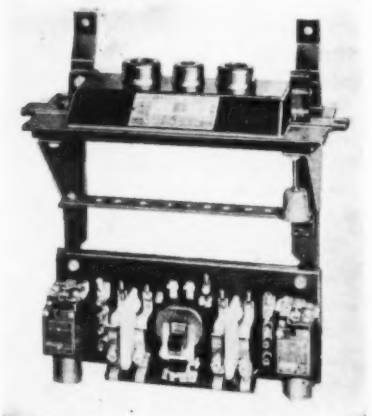
Fig. 2—Motor displaced from centerline of base to increase the belt tension

ward toward the center line of the base so that the bearing pressure is lessened. The list of drives carried in stock has been increased to 100 hp., 1800 r.p.m. Larger bases of special welded steel construction are made to order.

Square D Class 8528 Starters

Class 8528 explosion-proof, a.c. automatic starters, manufactured by the Industrial Controller Div., Square D Co., Milwaukee, Wis., have been approved by the Underwriters' Laboratory for use in Class 1, Group D hazardous locations. The starters are of the oil-immersed type and control across-the-line single and polyphase motors. Capacities range from 5 to 75 hp.

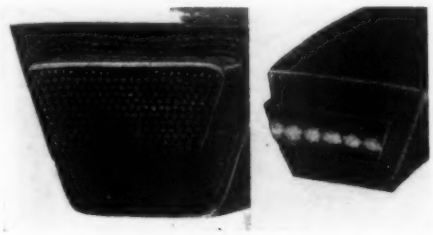
The starter consists of a cast-iron head, welded steel tank and starter panel. The head casting, which is provided with brackets for wall mounting, supports the steel angle



frame to which the panel is secured and the oil tank. The panel consists of a three-pole magnetic contactor and two oil dashpot overload relays. A visible gage indicates the maximum, normal and minimum oil levels in the tank. A special arrangement prevents the deterioration of incoming leads and capillary action.

"Condor" V-Belt

A V-belt with no inelastic stretch has been developed by The Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., Passaic, N. J. This is accomplished by not using the same general construction for all sizes of V-belts. For light-duty, high-speed sizes, a flexible "Whipcord" construction is employed,



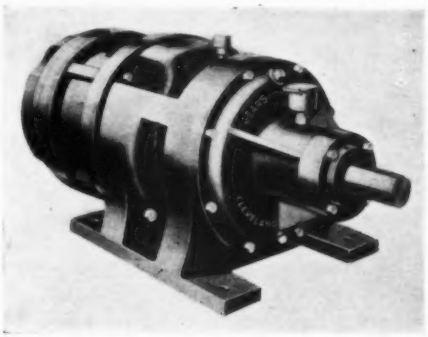
and for the heavy-duty service a more sturdy design known as "Plycord" has been evolved.

Condor Whipcord consists of one layer of continuously wound cords imbedded in two layers of tie-gum. The balance of the belt is filled out with extensible and compressible rubber with a closely-woven rubberized duck cover. Condor Plycord is made up of continuously wound plies of cord with one layer of tie-gum between each. After being built up to the correct thickness, it is cut to the correct angle of the belt, but otherwise is similar to Plycord.

Gears & Forgings Planetary-Type Motorized Speed Reducer

A speed reducer of the planetary type built integral with an electric motor to form a compact unit has been placed on the market by Gears & Forgings, Inc., Cleveland, Ohio. This motorized speed reducer is designed particularly for applications where available space for the driving mechanism is limited.

The housing for the reduction gears is dust-proof and oil-tight, and is integral with the base, which extends to the center line of the motor and provides rigid support to the gearing and the output shaft. No additional loads are imposed on the



motor shaft, which is supported by two ball bearings. Thirty-four standard ratios are available, ranging from 4:1 to 240:1 inclusive, and sizes range from $\frac{1}{4}$ to 30 hp.

Westinghouse Refractory-Protected Mercury Switch

The Westinghouse Lamp Co., 150 Broadway, New York, N. Y., has placed on the market a refractory-protected mercury switch for the following uses: temperature regulators, motor controls, sign flashers, lighting controls, time clocks, heating controls,

signals, gasoline pumps, and spraying equipment. To protect the glass walls of this switch a refractory block is placed within the switch, providing a chamber to confine the arc caused by the opening and closing of circuits having surge characteristics. The refractory protecting chamber is designed to insure a positive, safe and dependable impact contact between two pools of mercury.

"E. C. & M." No. 1, Type ZEO Explosion-Proof Starter

Explosion-proof characteristics of the No. 1, Type ZEO across-the-line starter, manufactured by The Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio, have been approved by the Underwriters' Laboratories for Class 1, Group D hazardous locations. The inclosing case is strong and tight enough to prevent the transmission of flame that may occur within the case to the surrounding atmosphere, and the flanged joint between the upper and lower parts of the case is of sufficient length to cool gases within before they can come in contact with the surrounding atmosphere. The mechanism and over-load relays are mounted on a slate base, which is removable. The main contacts and over-load relay contacts are oil immersed. Terminals are located above the level of oil. Maximum ratings are 5 hp., 110 volts and 10 hp., 220, 440 and 550 volts. For controlling the starters, the Type EO explosion-proof push button is used.

"Brastil" High-Strength Die Castings

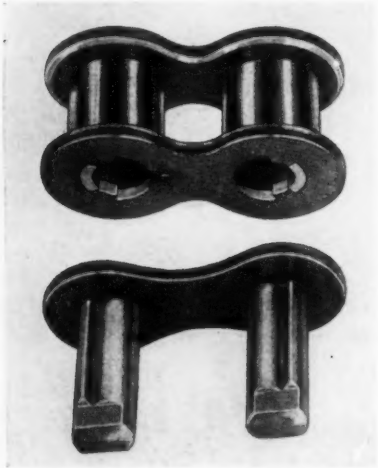
"Brastil" is a copper-base alloy developed by the Doehler Die Casting Co., 386 Fourth Ave., New York, N. Y., for die castings which must have high strength. Other properties of the alloy are high hardness, easy machinability, high resistance to fatigue and shock, good bearing qualities, high resistance to corrosion and a white gold color which makes the alloy suitable for beautiful oxidized finishes on decorated parts. The physical properties of Brastil are: tensile strength, ultimate, 90,000 to 95,000 lb. per sq.in.; elongation, 10 to 17 per cent in 2 in.; hardness, 160 to 180 Brinell, and weight, 0.29 lb. per cu.in.

The resistance of Brastil to acids, alkalies and salts is said to be equal to that of any known copper alloy. The alloy will withstand higher loads than ordinary bearing bronzes. The material can be cut, tapped, reamed, drilled and turned without difficulty,

and can also be soldered and welded. Parts now made from steel because of the need for strength and rigidity can be die cast in Brastil and will have the properties of steel, freedom from rust, and be available in the wide latitude of shapes afforded by the die-casting art.

Morse Roller Chain

A roller chain with distinctly different joint construction has been developed by the Morse Chain Co., Ithaca, N. Y. Within the roller there are two joint members, a segmental bushing and a pin. The cross-section of the pin is that of a round pin integral with a segmental bushing. Because of this construction, when a chain is flexing on or off a sprocket, all sliding movement of the surfaces under load



is between the pin and its bushing, and no movement occurs between the roller and joint members when under load. This feature insures uniformity of pitch throughout the life of the chain, and smoother and quieter operation.

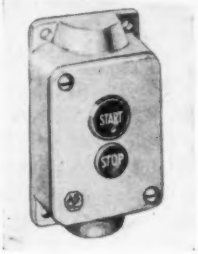
The open spaces between the joint members provide reservoirs for oil, and lubrication is made more effective by the "pumping" action when flexing. The chain is made to manufacturer's standards and is interchangeable on all standard roller sprockets.

Permite Resalum Aluminum Paint

Permite Resalum, marketed by the Aluminum Industries, Inc., Cincinnati, Ohio, is an aluminum paint incorporating a special vehicle. The paint is supplied ready mixed and may be applied to wood, metal, fibre, stone or wherever a preservative paint is required. The coverage is claimed to be twice that for similar products. Permite Resalum is heat resisting and therefore may be applied to boiler fronts, steam lines, smokestacks, annealing ovens, and furnaces. It is non-corrosive and may be applied to pickling room equipment and other places where it is necessary to protect against corrosion by a continuous film of metal. It is moisture-proof, and remains unaffected by weather conditions. Light reflectivity of the product is between 60 and 70 per cent of the total light which falls upon it.

Allen-Bradley Heavy-Duty Push-Button Stations

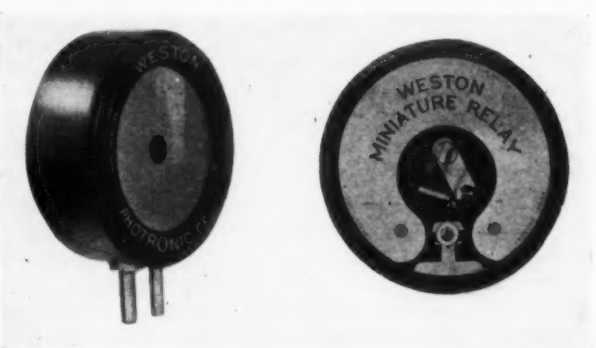
Heavy-duty, push-button stations for use where heavy currents must be handled, or where the push-button duty cycle is severe, have been placed on the market by the Allen-Bradley Co., 1311 South 1st St., Milwaukee, Wis. The high capacity of the push-button mechanism is obtained by the use of silver-to-silver contacts and multiple breaks.



In these stations one, two or three buttons can be supplied in a pressed steel box or one or two buttons in a cast-iron box. Water-tight or explosion-proof control stations are available in cast-iron boxes.

Weston Model 594 Photronic Cell

In the Model 594 photronic cell, developed by the Weston Electrical Instrument Corp., Waverly Park, Newark, N. J., a highly light-sensitive disk transforms light energy directly into electrical energy without the use of an auxiliary voltage. The response of the device to light variations is instantaneous, and sufficient current is developed to operate directly Weston relays without the use of auxiliary apparatus. The current delivered is about 1 micro-ampere per foot-candle of light intensity. The cell is inclosed in a molded black case fitted at the bottom with two connection prongs, which fit into the standard UX radio tube socket. The case is $2\frac{1}{4}$ in. in diameter and 1 in. in thickness.



Marsh Self-Cleaning Pipe-Line Strainer

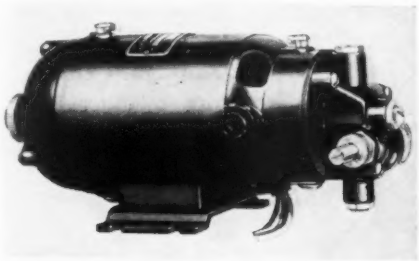
A self-cleaning strainer for installation on the return lines of low, medium and high-pressure systems operating at up to 125 lb. per sq.in. has been developed by Jas. P. Marsh & Co., 2073 Southport Ave., Chicago, Ill. This strainer will eliminate dirt, grit and scale, and can be installed either horizontally or vertically. It is self-cleaning and self-draining

when the plug is out or the blow-off valve is open.

The body and strainer plug are of cast iron. The strainer cylinder is a perforated truncated cone. The standard cylinder for steam, water, air, gas and oil is made of brass with $\frac{1}{16}$-in. perforations. For other services cylinders of special metals and with special perforation sizes can be supplied. The strainer is made in $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 in. pipe size. All sizes are made with a $\frac{1}{2}$-in. blowoff.

Bodine Constant-Speed Universal Motors

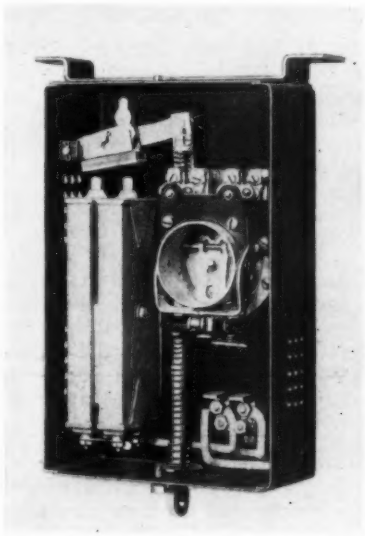
A line of series-wound motors with improved electric governors is now offered by the Bodine Electric Co., 2264 W. Ohio St., Chicago, Ill. This governor has been applied to talking motion picture equipment,



electric pyrometer control drives, office appliances, and traffic signal control. Although most frequently applied to the series-wound motor, this governor may also be used with the shaded-pole type motors.

Allen-Bradley Treadle-Operated Controllers

Bulletin 500, treadle-operated controllers, recently announced by the Allen-Bradley Co., 1311 South First St., Milwaukee, Wis., provide a convenient means for a smooth control of speeds of small tools, sewing machines, winding machines and others



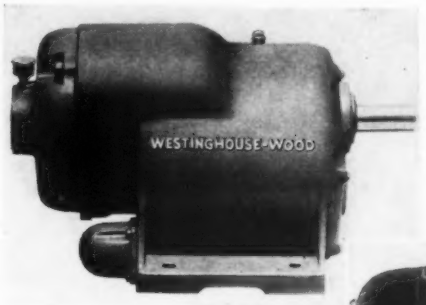
required to be driven by d.c. or universal motors. Operation of the treadle compresses a graphite-disk compression resistor.

These controllers are made in five sizes, the largest being rated at ½ hp.

Westinghouse-Wood Motorized Gear Units

The H. C. Wood Machine Works, 514 Bryant St., San Francisco, Calif., has brought out "Westinghouse-Wood" electric-motor gear units composed of Westinghouse electric motor parts combined with helical gears held in place by oversized ball bearings. These units are compact and are slightly larger than the ordinary motor. The base measures 9x12 in.

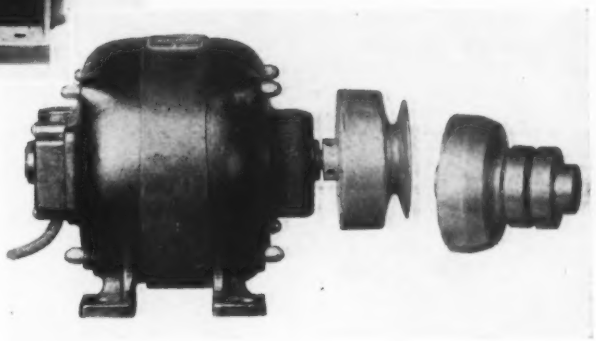
The units may be obtained to give 900 to 60 r.p.m. on the outgoing shaft, using an 1,800 r.p.m. motor, or any



speed down to 30 r.p.m., using a 900 r.p.m. motor. A slow-speed shaft can be had on one end and a standard-speed-shaft on the opposite end. Sizes to 7½ hp. are carried in stock.

General Electric Washing-Machine Clutch Motor

A low-starting-current, washing-machine clutch motor for use on 110-volt, 60-cycle circuits has been announced by the General Electric Co., Schenectady, N. Y. The fractional-horsepower motor, offered as a supplement to the standard KSA line of washing-machine motors, is wound for low-starting-current operation when used with a clutch unit assembled on the motor shaft. The starting current is approximately half of that previously used for this type of work. This results in less disturbance on the lighting circuit. The clutch motor is available for V-belt drive with a pulley incorporated in the clutch unit or direct drive with a flexible coupling. The clutch is the centrifugal type.



New Books and Publications

INTERNAL-COMBUSTION ENGINES. *By Howard E. Degler, professor and chairman, Department of Mechanical Engineering, University of Texas. 154 pages, 6x8 in. Clothboard covers. Illustrated. Published by the American Technical Society, Chicago, Ill. Price $2.*

THIS book is primarily an elementary treatise on internal-combustion engines, the fundamental thermal equations being presented without proof and considerable space being devoted to a description of engines and auxiliaries in common use. In the first 30 pages of the text, the author presents the thermo-dynamics of the Otto cycle and the Diesel cycle, together with equations for calculating indicated horsepower. Typical examples are worked out for illustrating the methods for applying these equations. However, because of the entire absence of proofs and derivations, the material is of little value except for reference purposes or those who desire to merely memorize the equations.

Following a brief discussion on fuels, the author goes into comprehensive descriptions of typical Otto-cycle and Diesel-cycle engines. Herein lies the greatest value of the book. The descriptions are complete but brief. By the use of short, concise sentences, the author has succeeded in crowding many thoughts into a small space, yet retaining complete clarity of expression. Internal-combustion engine auxiliaries are treated in a similar manner.

INDUSTRIAL ELECTROCHEMISTRY. *By C. L. Mantell, Ph.D., consulting chemical engineer. 528 pages, 6x9 in. Clothboard covers. Indexed. Appendixed. 178 illustrations and 51 tables. Published by the McGraw-Hill Book Company, Inc., 330 West 42nd St., New York, N. Y. Price $5.00.*

Engineering phases of industrial electrochemistry have commonly been relegated to the background. But here is a volume that emphasizes the technological importance of electrochemistry, stresses its practical aspects and adopts the engineering viewpoint. This

New Books and Publications

(Continued)

volume of the McGraw-Hill Chemical Engineering Series is well written and edited by specialized experts. It is planned not merely as a college chemical engineering text, but as a reference work for industry in general, and contains a large amount of tabular and charted information. The appendix is especially complete.

KINEMATICS OF MACHINERY. *By C. D. Albert and F. S. Rogers, professors of machine design, Cornell University. 527 pages, 6x9 in. Clothboard covers. Indexed. About 600 illustrations. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price, $4.50.*

An outgrowth of the authors' experience in teaching kinematics to engineering students, this volume is written primarily for colleges and presupposes a course in engineering mechanics. It contains the necessary subject matter for a 45-period recitation course, with additional material for a course in advanced kinematics and kinetics. It also emphasizes certain aspects of cam and gear design and includes a general method of determining the linear velocity and acceleration of any point in a mechanism and the angular velocity and acceleration of any link. Notation is careful, consistent and convenient, illustrations are unusually suitable, many of them to scale. A number of questions and problems are included at the back.

PROCEEDINGS OF THE THIRTY-FOURTH ANNUAL MEETING. *Issued by the American Society for Testing Materials. Part I, 1,119 pages, and Part II, 1,027 pages, 9x6 in. Clothboard cover. Published by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Price, each part $5.50, paper binding; $6, cloth binding; $7, half-leather.*

PART I of the 1931 A.S.T.M. Proceedings contains the annual reports of various committees of the Society and papers and standards, together with the president's annual address and the annual report of the executive committee. Reports cover the work of 42 standing and research committees and one joint committee and two sectional committees on ferrous metals, non-ferrous metals, and non-metallic materials. There are 74 tentative standards given, and several tentative revisions in standards, in addition to other committee reports on methods of testing, metallography, nomenclature, and definitions.

Part II of the 1931 Proceedings contains the technical papers that were given at the annual meeting of the Society. The principal subjects include papers on the various aspects of fatigue, endurance testing, magnetic analysis, damping capacity and corrosion of metals, a symposium on malleable iron castings comprising 118 pages of authoritative critical data, a symposium on the abrasion testing of rubber, covering 60 pages, and a paper on the economic significance of specifications for materials. In addition there are many papers on structural and building materials and color pigments.

NOISE AND VIBRATION ENGINEERING. *By Stephen E. Slocum, Ph.D., Consulting Engineer. 171 pages, 6x9 in. Clothboard covers. Indexed. Illustrated. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Price $2.75.*

Only during the last year or two has the progress of noise reduction been rapid. This volume, after discussing the theory of sound transmission, covers the subject of noise from its mathematical groundwork to the application of noise isolation on machines. The engineer will find interesting Chapter II on "Properties of Vibration Dampers and Insulators," Chapter VI on "Machinery Insulation, Sound Deadening, and Acoustic Correction," and Chapter IX, which gives a selected bibliography of books and papers on the subject.

▼

A.S.T.M. STANDARDS. The American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa., has issued the 1931 Index to A.S.T.M. Standards and Tentative Standards as of September, 1931.

BELT DRIVES. The Engineering Experiment Station of Ohio State University, Columbus, Ohio, has issued Bulletin 62 entitled "Belt Drives with Cast-Iron Pulleys and with Paper Pulleys." Investigation was made of the transmissive power of oak-tanned leather belts and rubber belts, particularly at small angles of contact, on these two types of pulleys. Twenty-five graphs are included in the text.

CHAINS AND SPROCKETS. The Baldwin-Duckworth Chain Corp., Springfield, Mass., has issued a catalog "Duckworth Power Transmission Chains and Sprockets" on roller chains, block chains, special-purpose chains, attachment links and sprockets. The bulletin contains a complete listing of all sizes manufactured with the dimensions and horsepower ratings, together with engineering information. A roller chain selection chart is a special feature.

FRICTION OF BEARINGS. The Engineering Experiment Station of the University of Wisconsin, Madison, Wis., has issued Bulletin No. 72 entitled "Friction of Some Babbitt, Roller and Ball Bearings." The general purpose of all tests was to determine the friction of some commercial lineshaft bearings under circumstances to warrant some fair comparisons of their frictional resistances.

GEARMOTORS. The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has issued Leaflet 20536 on "Gearmotors," consisting of speed reducers combined with induction motors into general purpose unit drives. Information on application and operation, details of construction, a listing of sizes and speeds, and dimensions are contained in the leaflet.

MOTORS. The Bodine Electric Co., Oakley Blvd. & Ohio St., Chicago, Ill., has issued Bulletin No. 1007-B, on constant-speed motors of 1/20, 1/15 hp. at 1,725 r.p.m., and 1/40 and 1/30 hp. at 1,125 r.p.m. for a.c. and d.c. general purposes.

MOTORS. The Master Electric Co., Dayton, Ohio, has issued Data Book Section 210, on its geared-head motors for gear reduction or acceleration. The reduction or acceleration unit is built into the motor housing. Many typical products to which these geared-head motors have been applied are also illustrated.

RHEOSTATS. The General Electric Co., Schenectady, N. Y., has issued bulletin GEA-1084A, superseding 1084, on plate-type field rheostats for hand regulation of voltage on generator fields and for speed adjustment on constant- and adjustable-speed motors.

TANTALUM. The Fansteel Products Co., Inc., North Chicago, Ill., has issued a folder "Some Examples of the Corrosion-Resistant Properties of Tantalum." The folder gives a complete table of the corrosion tests of tantalum with various acids and alkalis and also lists the physical properties.

TORQUE MOTORS. The Ohio Electric Mfg. Co., 5900 Maurice Ave., Cleveland, Ohio, has issued Bulletin 208 on slow-speed torque motors or rotating magnets, which have ability to stall across the line. Applications include closing and holding closed electrical contactors, valve stems and locking or clamping devices.

VALVES. The Reading-Pratt & Cady Co., Inc., Bridgeport, Conn., has issued a 16-page book on its Lubrotite gate valve, which differs from the ordinary gate valve in that it has a duct system for introducing a lubricant-seal between the seating surfaces.

VALVES. The Homestead Valve Mfg. Co., Inc., Coraopolis, Pa., has issued a complete reference book on valves, containing 48 8½x11-in. pages.

VANADIUM STEELS. The Vanadium Corp. of America, 120 Broadway, New York, N. Y., has re-issued specification sheets 3B to 9B, inclusive, on vanadium steels for locomotive castings, railway springs of various types, and automobile springs.